Symmetry-protected nodal points and nodal lines in magnetic materials

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Nodal-point and nodal-line structures in the dispersion of electron energy bands are characterized by their high degeneracy in certain corners or lines in the Brillouin zone (BZ). These nodal structures can also exist in the dispersion of itinerant electrons in magnetically ordered materials whose symmetry groups are antiunitary groups called the magnetic space groups. In the present paper, we provide a complete list of magnetic space groups, which can host symmetry-protected nodal-point/line band structures for spin-1/2 fermionic particles, where the degeneracies at the nodal points/lines are guaranteed by irreducible projective representations (IPReps) of the little cogroups. Our discussion is restricted to the magnetic space groups whose magnetic point group contains the space-time inversion operation $\tilde{T} = \mathcal{I}T$, the combined operation of spacial inversion $\mathcal{I}$ and time reversal T, such that the energy bands are at least doubly degenerate at arbitrary points in the BZ. For these magnetic point groups we provide the invariants to label the classes of projective Reps, and for each class we calculate all the inequivalent IPReps. From the results we select out all the groups and the corresponding Rep classes, which support high-dimensional ($d \geqslant 4$) IPReps. We then list the magnetic space groups and their high-symmetry points/lines whose little cogroups have high-dimensional ($d \geqslant 4$) IPReps with the corresponding factor systems. Examples of candidate materials are discussed.

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I. INTRODUCTION

Gapped topological phases of matter such as topological insulators [1–3] or topological superconductors [4,5] have nontrival band structures and novel transport properties. Some gapless materials called the topological semimetals also exhibit anomalous transport phenomena such as the negative magnetic resistance effect [6,7] and the so-called planar Hall effect [8]. Typical examples include the well studied Dirac semimetals and Weyl semimetals, whose low-energy physical properties are similar to the Dirac fermions and Weyl fermions in high-energy physics, respectively. Furthermore, some low-energy quasiparticles in condensed matter have no counterpart in high-energy physics, such as the semimetals with nodal lines or quadratic nodal points, which have also attracted lots of interests. For the systems whose magnetic point group contains the combined operation $\mathcal{I}T$ of spatial inversion $\mathcal{I}$ and time reversal T, namely, if $\{\mathcal{I}T|\tau_{\mathcal{T}}\}$ (with $\tau_{\mathcal{T}}$ a zero or nonzero fractional translation) is a symmetry element of the magnetic space group, then the energy band has Kramers degeneracy in the whole Brillouin zone (BZ) with the degrees of the degeneracy $d \geqslant 2$. In this case, the nodal point/line structures are characterized by high degrees of degeneracy with $d \geqslant 4$. For instance, the 2-dimensional Dirac semimetal [9] was found in honeycomb lattice such as the graphene, where the 4-fold degeneracy of the nodal point is protected by spin-rotation symmetry and the D_{3d} point-group symmetry. In 3-dimensional spin-orbital coupled materials, the 4-fold degeneracy of the Dirac cones at the high-symmetry points (HSPs) are protected by IPReps of the little cogroups. Especially, for certain nonsymmorphic space groups, the 4-fold degeneracy is guaranteed since the lowest dimension of the IPReps of the little cogroup is four [10].

While the topological semimetals in nonmagentic materials have been profoundly studied [10–33], nodal-point/line band structures for the itinerant electrons in magnetically ordered systems are less known [34–41]. Besides the difference in the intensities of electronic correlation interactions, the magnetically ordered materials mainly differ with the nonmagnetic ones by their symmetry groups. For the nonmagnetic crystals, their spacial symmetries are described by the 230 space groups, also called the type-I Shubnikov magnetic space groups. (Since time reversal is generally a symmetry, the complete symmetry group of a nonmagnetic crystal is the direct product of a space group and the time-reversal group, called the type-II Shubnikov magnetic space group). For magnetic materials, the time-reversal symmetry is explicitly broken but the combination of time reversal and certain rotation or fractional translation remains to be a symmetry. In this case, the complete symmetry group is either a type-III or a type-IV Shubnikov magnetic space group. Owing to the rich structure of the antiunitary groups, the type-III and type-IV magnetic

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space groups can yield rich band structures for the itinerant electrons in magnetic materials.

In the present paper, we study symmetry-protected nodal-point and nodal-line structures for spin-1/2 fermionic particles in magnetic semimetals, where the multipole degeneracies are guaranteed by IPReps of the little cogroups. We only consider the case where the energy bands are always at least doubly degenerate away from the high-symmetry points/lines, this requires that the combined operation $\tilde{T}$ is an element of the little cogroup of magnetic space group (this means that $\{\tilde{T}|\boldsymbol{\tau}_{\tilde{T}}\}$ is an element of the magnetic space group, where $\boldsymbol{\tau}_{\tilde{T}}$ is either a fractional translation or a zero vector). By calculating the IPReps of the little cogroups, we provide a complete list of magnetic space groups (which contain $\{\tilde{T}|\tau_{\tilde{T}}\}$ as a symmetry element) and the high-symmetry points/lines, which support the high degeneracy ($d \geqslant 4$). We also provide the dispersion around the nodal points/lines. These results provide important information for experimental realization of nodal-point/line semimetals in magnetic materials.

The paper is organized as follows. In Sec. II, we provide the IPReps of the magnetic point groups, which contain the $\tilde{T} = \mathcal{I}T$ operation. We considered all classes of projective Reps, which are classified by the second group cohomology. For each classes, we calculate all the inequivalent IPReps. In Sec. III, we provide the criterion to judge the dispersion around the high-degeneracy points/lines, from which we can judge if the dispersion around a nodal point is a Dirac cone or a quadratic band touch, or a combination of them. The conditions for the existence of nodal-line band structures are also provided. Section IV is an instruction to read the information listed in the tables, where the central results of the present paper are summarized in Table I. Some potential materials are proposed in Sec. V. Section VI is devoted to the conclusions and discussions.

II. SPECTRUM DEGENERACY: IPReps OF THE LITTLE COGROUPS

For a finite group G, the group element g is represented by $M(g)$ if g is a unitary element and represented by $M(g)K$ if g is antiunitary, where $M(g)$ is a unitary matrix, K is the complex-conjugate operator satisfying $KU = U^*K$ with U an arbitrary matrix and U^* its complex conjugation. The projective Rep of G is defined as [42]

$$M(g_1)K_{s(g_1)}M(g_2)K_{s(g_2)} = \omega_2(g_1, g_2)M(g_1g_2)K_{s(g_1g_2)}, \quad (1)$$

for $g_1, g_2 \in G$, where $s(g) = -1$, $K_{s(g)} = K$ if g is antiunitary and $s(g) = 1$, $K_{s(g)} = I$ (identity matrix) if g is unitary, $\omega_2(g_1, g_2)$ is the factor system of projective Reps with $|\omega_2(g_1, g_2)| = 1$. If $\omega_2(g_1, g_2) = 1$ for any $g_1, g_2 \in G$, above projective Rep is trivial, namely, it is a linear Rep. Under a gauge transformation $M'(g)K_{s(g)} = M(g)\Omega_1(g)K_{s(g)}$ with $|\Omega_1(g)| = 1$, the Eq. (1) changes into

$$M'(g_1)K_{s(g_1)}M'(g_2)K_{s(g_2)} = \omega_2'(g_1, g_2)M'(g_1g_2)K_{s(g_1g_2)}, \quad (2)$$

with the factor system

$$\omega_2'(g_1, g_2) = \omega_2(g_1, g_2)\frac{\Omega_1(g_1)\Omega_1^{s(g_1)}(g_2)}{\Omega_1(g_1g_2)}. \quad (3)$$

The two factor systems ω_2 and ω_2' belong to the same class. We only use one factor system $\omega_2(g_1, g_2)$ of each class to construct the regular projective Rep of G (see Appendix A). The IPReps of G can be obtained by reducing the regular projective Rep of G.

As mentioned, we consider the type-III or type-IV Shubnikov space groups as the symmetry groups of magnetic materials. For the type-III Shubnikov space groups [43], every antiunitary symmetry element $T\{g|\boldsymbol{\tau}_g\}$ is a combination of time reversal T and certain space group operation with fractional translation $\boldsymbol{\tau}_g$ in which the point-group operation $g \neq E$. Therefore this type of groups have the structure $\mathcal{M} = \mathcal{H} + T(G - \mathcal{H})$, where $\mathcal{H}$ is a halving subgroup of Fedorov (ordinary) space group G. In this case, time-reversal operation T is not an element of $\mathcal{M}$. On the other hand, in a type IV Shubnikov space group [43] the combination of time reversal T and certain fractional translation $\boldsymbol{\tau}_0$ is a symmetry operation. Therefore this type of groups have the structure $\mathcal{M} = G + T\{E|\boldsymbol{\tau}_0\}G$, where G is a Fedorov space group.

In the Rep theory of a type-III or type-IV Shubnikov magnetic space group $\mathcal{M}$, the magnetic little group $\mathcal{M}(\boldsymbol{k})$ is the subgroup of $\mathcal{M}$, which transforms the wave vector $\boldsymbol{k}$ in the BZ into its equivalent wave vector $\boldsymbol{k} + \boldsymbol{K}$, here $\boldsymbol{K}$ is a reciprocal lattice vector. $\mathcal{M}(\boldsymbol{k})$ is also a Shubnikov space group, which has translation group as its normal subgroup. The (magnetic) point group of $\mathcal{M}(\boldsymbol{k})$ is called (magnetic) little cogroup $G_0(\boldsymbol{k})$, which is the quotient group of $\mathcal{M}(\boldsymbol{k})$ with respect to the translation group.

The isogonal point group of Shubnikov space group $\mathcal{M}$ is $\mathcal{M}_0$. To get symmetric group $P(\boldsymbol{k})$ of $\boldsymbol{k}$ at high symmetry point or high-symmetry line, double the group elements of $P(\boldsymbol{k})$ in Table 3.6 of Ref. [43] by multiplying all the group elements by $\mathcal{I}T$. The little cogroup $G_0(\boldsymbol{k})$ is intersection of $\mathcal{M}_0$ and $P(\boldsymbol{k})$, i.e., $G_0(\boldsymbol{k}) = \mathcal{M}_0 \cap P(\boldsymbol{k})$.

A remarkable property of a linear Rep of the Shubnikov space group $\mathcal{M}$ is that it defines a projective Rep (1) of the little cogroup $G_0(\boldsymbol{k})$ for a momentum $\boldsymbol{k}$ if it is a high-symmetry point (HSP) or a point on a high-symmetry line (HSL) defined in the BZ. Except for accidental degeneracy, for itinerant electrons in magnetically ordered materials, the degeneracy of the energy bands at a given momentum $\boldsymbol{k}$ of HSP or HSL in the BZ is generally protected by IPReps of $G_0(\boldsymbol{k})$.

For Shubnikov magnetic space group $\mathcal{M}$, the fractional translations associated with the point-group operations contribute to the factor system of the projective Rep of $G_0(\boldsymbol{k})$ as the following [43–45],

$$\omega_{2b}(g_1, g_2) = e^{-i\boldsymbol{K}_1\cdot\boldsymbol{\tau}_2}, \quad (4)$$

where reciprocal lattice vector $\boldsymbol{K}_1 = s(g_1)(g_1^{-1}\boldsymbol{k} - \boldsymbol{k})$, $\boldsymbol{\tau}_2$ is fractional translation associated with $g_2 \in G_0(\boldsymbol{k})$, and $s(g_1) = -1$ if g_1 is antiunitary otherwise $s(g_1) = 1$. If $\mathcal{M}$ is symmorphic space group, the fractional translation τ_g is zero for any $g \in G_0(\boldsymbol{k})$, the factor system $\omega_{2b}(g_1, g_2) = 1$ for any $g_1, g_2 \in G_0(\boldsymbol{k})$. Above factor system $\omega_{2b}(g_1, g_2)$ is completely determined by the group elements of $\mathcal{M}$. As shown in Appendix B, Eq. (4) satisfies the cocycle equation

$$\omega_{2b}(g_1, g_2)\omega_{2b}(g_1g_2, g_3) = \omega_{2b}^{s(g_1)}(g_2, g_3)\omega_{2b}(g_1, g_2g_3). \quad (5)$$

TABLE I. Information for the IPReps for fermionic particles at the HSPs of Shubnikov magnetic space groups, where "dim" denotes the dimension of the IPReps in the given class. If dim = 4 then all the IPReps of the same class are of 4-dimensional, the case dim = 8 is similar; if dim = 4|8 then first number 4 stands for the lowest dimension of the IPReps of the same class and the second number 8 is the dimension of the present IPRep, similar situations occur for dim = 4|4, 2|4, 2|6. For a given class (namely, the same HSP), if there are more than one IPReps with the same dimension but different dispersions, then we use the subscript $_{1,2,..}$ to distinguish these Reps. "l.c." stands for label of classification (i.e., the values of the gauge invariants) of projective Reps of magnetic little cogroups $G_0(\boldsymbol{k})$; "disp." means the dispersion at the vicinity of the given HSP (linear, quadratic or cubic $\boldsymbol{k}$ terms that split the band degeneracy are provided, higher-order terms are not shown); "n.l." shows the directions of nodal lines (if any) crossing the HSP. $k_{x\pm y}$ denotes $k_x \pm k_y$, so on and so forth.

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
11.55 IV	Z	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	C	$C_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	D	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	E	$C_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
11.57 IV	C	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	E	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
13.70 IV	B	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	D	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
13.71 IV	B	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	D	$C_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	A	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	E	$C_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
13.73 IV	D	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	E	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
13.74 IV	B	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	D	$C_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	E	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
14.80 IV	B	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	Z	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	C	$C_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
14.81 IV	B	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	A	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
14.82 IV	Z	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	C	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
14.84 IV	B	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	C	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
15.91 IV	A	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	M	$C_{2h}^1 \times Z_2^T$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
47.254 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
47.255 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,+1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,+1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
47.256 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,+1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,+1,+1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
48.261 III	Y	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	Z	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
	U	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y, k_z	
	T	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	S	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
48.262 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	k_x, k_y, k_z	
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,-1,+1)$	k_x, k_z, k_xk_y	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,+1,-1)$	k_x, k_y, k_z	
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,-1,-1)$	k_x, k_y, k_xk_z	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
48.263 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,-1,+1)$	k_x, k_z, k_xk_y	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,-1)$	k_y, k_z, k_xk_y	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,-1,-1)$	$k_x, k_y, k_xk_yk_z, \ldots$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
48.264 IV	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,-1,+1)$	$k_x, k_z, k_xk_yk_z, \ldots$	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,-1,+1,-1)$	$k_y, k_z, k_xk_yk_z, \ldots$	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,-1,-1)$	$k_x, k_y, k_xk_yk_z, \ldots$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
49.271 III	Z	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
	U	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
	T	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
49.272 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,-1,-1)$	k_x, k_y, k_xk_z	k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,-1,-1)$	k_x, k_y, k_xk_z	k_z
49.274 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,+1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,-1,-1,-1)$	k_x, k_y	k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,+1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,-1,-1,-1)$	k_x, k_y	k_z
49.275 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,+1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,-1,-1)$	k_x, k_y, k_xk_z	k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,-1,-1)$	k_x, k_y, k_yk_z	k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,-1,-1)$	$k_x, k_y, k_xk_yk_z, \ldots$	k_z
49.276 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,+1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,-1,-1)$	k_x, k_y	k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,-1,-1,-1)$	k_x, k_y	k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, -1, -1, -1)$	k_x, k_y	k_z
50.283 III	Y	$D_2^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	U	$D_2^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	T	$D_2^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
	S	$D_2^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
	R	$D_2^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
50.284 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, -1)$	k_x, k_y, k_xk_z	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, -1)$	k_x, k_y, k_xk_z	k_z
50.285 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	k_y, k_z, k_xk_z	k_x
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	k_x, k_z, k_yk_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
50.286 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	k_y, k_z, k_xk_z	k_x
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, +1)$	k_x, k_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, -1, -1)$	k_x, k_y, k_yk_z	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, -1)$	k_x, k_y	k_z
50.287 IV	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, -1, -1)$	$k_x, k_y, k_xk_yk_z, \ldots$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, -1, -1)$	$k_x, k_y, k_xk_yk_z, \ldots$	k_z
50.288 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, -1)$	k_y, k_z	k_x
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, +1)$	k_x, k_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, -1, -1)$	$k_x, k_y, k_xk_yk_z, \ldots$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, -1, -1, -1)$	k_x, k_y	k_z
51.293 III	X	$C_{2v}^3 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
	U	$C_{2v}^3 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
	S	$C_{2v}^3 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
	R	$C_{2v}^3 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
51.299 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, -1, +1)$	k_y, k_xk_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, -1, +1)$	k_y, k_xk_y, k_xk_z	k_x, k_z
51.300 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, -1, +1)$	k_y, k_xk_z	k_x, k_z
51.301 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, -1, +1)$	k_y, k_xk_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, -1, -1, +1)$	k_y, k_xk_z	k_x, k_z
51.302 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, +1)$	k_y, k_z, k_xk_z	k_x
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, +1)$	k_y, k_z, k_xk_z	k_x
51.303 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, +1)$	k_y, k_xk_z	k_x, k_z
51.304 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, +1)$	k_y, k_z, k_xk_z	k_x
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, -1, +1)$	k_y, k_xk_z, k_yk_z	k_x, k_z
52.307 III	Y	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
	S	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
52.309 III	S	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
52.313 III	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	Z	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
	U	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
52.314 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, +1)$	k_x, k_z, k_xk_y	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, -1, +1)$	k_y, k_xk_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, +1, -1)$	k_x, k_xk_y, k_yk_z	k_y, k_z
52.315 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
52.316 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	k_x, k_z, k_yk_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, +1, -1)$	k_x, k_yk_z	k_y, k_z
52.317 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	k_x, k_z, k_yk_z	k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
52.318 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$k_x, k_z, k_xk_yk_z, \ldots$	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, -1, +1)$	k_y, k_xk_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, -1, +1, -1)$	k_x, k_yk_z	k_y, k_z
52.319 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, +1)$	k_x, k_z, k_xk_y	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, +1, -1)$	$k_x, k_y k_z$	k_y, k_z
52.320 IV	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$k_x, k_z, k_x k_y k_z, \ldots$	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	$k_x, k_y, k_x k_z$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, +1, -1)$	$k_x, k_x k_z, k_y k_z$	k_y, k_z
53.324 III	Z	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
	T	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
53.329 III	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	S	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
53.330 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	$k_x, k_z, k_y k_z$	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	$k_x, k_z, k_y k_z$	k_y
53.331 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_x k_y, k_x k_z, k_y k_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	$k_x, k_z, k_y k_z$	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, +1, -1)$	$k_x, k_y k_z$	k_y, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, -1)$	$k_y, k_z, k_x k_y$	k_x
53.332 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
53.333 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_x k_y, k_x k_z, k_y k_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, +1, -1)$	$k_x, k_y, k_y k_z$	k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, -1)$	$k_y, k_z, k_x k_y$	k_x
53.335 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_x k_y, k_x k_z, k_y k_z$	k_x, k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	$k_x, k_z, k_y k_z$	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, +1, -1)$	$k_x, k_y k_z$	k_y, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, +1, -1)$	k_y, k_z	k_x
53.336 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_x k_y, k_x k_z, k_y k_z$	k_x, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, +1, -1)$	$k_x, k_y, k_y k_z$	k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, +1, -1)$	k_y, k_z	k_x
54.340 III	U	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_z	k_y
	R	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_z	k_y
54.341 III	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
	U	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
	S	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
54.345 III	Z	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
	T	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
54.346 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
54.347 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_x k_y, k_x k_z, k_y k_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	$k_x, k_y, k_x k_z$	k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, +1, -1)$	$k_x, k_y k_z$	k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, -1, -1)$	$k_x, k_y, k_y k_z$	k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, -1, +1)$	$k_y, k_x k_y, k_x k_z$	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, +1, -1)$	$k_x, k_x k_y, k_y k_z$	k_y, k_z
54.348 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	$k_x, k_y, k_x k_z$	k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, +1, -1)$	$k_x, k_x k_z, k_y k_z$	k_y, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	$k_x, k_y, k_x k_z$	k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, +1, -1)$	k_x, k_xk_z, k_yk_z	k_y, k_z
54.349 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, +1, -1)$	k_x, k_xk_z, k_yk_z	k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, -1)$	k_x, k_y	k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, -1, +1)$	k_y, k_xk_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, -1, +1, -1)$	k_x, k_yk_z	k_y, k_z
54.350 IV	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
54.351 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, -1, -1)$	k_x, k_y, k_yk_z	k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, +1, -1)$	k_x, k_y, k_yk_z	k_z
54.352 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, -1)$	k_x, k_y	k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, +1, -1)$	k_x, k_yk_z	k_y, k_z
55.355 III	Y	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
	T	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
	S	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
	R	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
55.356 III	S	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y	k_z
55.359 III	S	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
55.360 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
55.361 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, -1)$	k_x, k_z, k_xk_y	k_y
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, -1, -1)$	k_z, k_xk_y, k_xk_z	k_x, k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, -1, -1)$	k_z, k_xk_y, k_yk_z	k_x, k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, -1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
55.362 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, -1)$	k_x, k_z, k_xk_y	k_y
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, -1, -1)$	k_z, k_xk_y, k_xk_z	k_x, k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, -1)$	k_z, k_xk_y	k_x, k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, +1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
55.364 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, -1)$	k_z, k_xk_y	k_x, k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, -1)$	k_z, k_xk_y	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
56.367 III	T	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
	R	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
56.368 III	Y	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
	U	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
	T	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
	S	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y	k_z
56.371 III	Z	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
56.372 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, +1, -1)$	k_x, k_y, k_yk_z	k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, -1, -1)$	k_x, k_y, k_yk_z	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
56.373 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, +1, -1)$	k_x, k_y, k_yk_z	k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, +1, -1)$	k_x, k_xk_z, k_yk_z	k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, -1, +1)$	k_y, k_xk_z, k_yk_z	k_x, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, -1, -1)$	$k_x, k_y, k_xk_yk_z, \ldots$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, -1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
56.374 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, +1, -1)$	k_x, k_xk_z, k_yk_z	k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, +1)$	k_y, k_z, k_xk_z	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, -1)$	k_x, k_y, k_xk_z	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
56.375 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
56.376 IV	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, +1)$	k_y, k_z, k_xk_z	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
57.379 III	Y	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
	S	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_y, k_z	k_x
57.380 III	Z	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
	U	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
	T	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
	R	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
57.385 III	T	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
57.386 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, +1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, +1, -1)$	k_x, k_xk_z, k_yk_z	k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, +1)$	k_x, k_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, -1, -1)$	k_z, k_xk_y	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, -1, -1, +1)$	k_x, k_z	k_y
57.387 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,-1,+1)$	k_x, k_z, k_yk_z	k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,-1,+1)$	k_x, k_z, k_yk_z	k_y
57.388 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y, k_z, k_xk_y	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y, k_z, k_xk_y	k_x
57.389 IV	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	k_x, k_y, k_z	
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	k_x, k_y, k_z	
57.390 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y, k_z, k_xk_y	k_x
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,-1,+1,+1,-1)$	k_x, k_yk_z	k_y, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1,+1,-1,-1,-1,-1,-1)$	k_z, k_xk_y	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,-1,+1)$	k_x, k_z	k_y
57.391 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,+1,+1,-1)$	k_x, k_z, k_yk_z	k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1,+1,-1,-1,+1,+1,-1)$	k_x, k_xk_z, k_yk_z	k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,-1,+1)$	k_x, k_z, k_yk_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,-1,+1,-1,-1)$	k_x, k_z, k_xk_y	k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,-1,+1)$	$k_x, k_z, k_xk_yk_z, \ldots$	k_y
57.392 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,-1,+1,+1,-1)$	k_x, k_yk_z	k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	k_x, k_y, k_z	
	S	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,-1,+1,-1,-1)$	k_x, k_z, k_xk_y	k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,-1,+1)$	k_x, k_z, k_xk_y	k_y
58.395 III	Y	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_y, k_z	k_x
	S	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_y, k_z	k_x
58.396 III	S	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y	k_z
58.399 III	Z	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
	S	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
58.400 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y, k_z, k_xk_y	k_x
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,+1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,-1,-1)$	k_x, k_y, k_yk_z	k_z
58.401 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y, k_z, k_xk_y	k_x
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,-1,+1,-1,-1)$	k_x, k_z, k_xk_y	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,-1,-1,-1)$	k_x, k_y	k_z
58.402 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,-1,+1,-1,-1)$	k_x, k_z, k_xk_y	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,-1,-1)$	k_x, k_y	k_z
58.403 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
59.408 III	Y	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x, k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y	k_z
	U	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y	k_z
	T	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x, k_y	k_z
	S	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y	k_z
59.412 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,+1,-1)$	k_x, k_y, k_yk_z	k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, +1, -1)$	k_x, k_y, k_yk_z	k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, -1, -1)$	k_x, k_y, k_yk_z	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, -1, -1)$	k_x, k_y, k_yk_z	k_z
59.413 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, +1, -1)$	k_x, k_y, k_yk_z	k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, +1, -1)$	k_x, k_yk_z	k_y, k_z
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, -1, -1)$	$k_x, k_y, k_xk_yk_z, \ldots$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, -1, -1, -1)$	k_x, k_y	k_z
59.414 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, +1, -1, +1)$	k_y, k_xk_z	k_x, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, -1)$	k_x, k_y, k_xk_z	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, -1)$	k_x, k_y	k_z
59.415 IV	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
59.416 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, +1)$	k_y, k_z, k_xk_z	k_x
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
60.419 III	T	$C_{2v}^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_y, k_z	k_x
	R	$C_{2v}^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_y, k_z	k_x
60.420 III	Z	$C_{2v}^2 \times Z_2^{\bar{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
	T	$C_{2v}^2 \times Z_2^{\bar{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
60.421 III	X	$C_{2v}^3 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
	U	$C_{2v}^3 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y	k_z
60.425 III	Y	$D_2^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
	U	$D_2^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	R	$D_2^1 \times Z_2^{\bar{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
60.426 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, -1)$	k_z, k_xk_y	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	k_y, k_z, k_xk_z	k_x
60.427 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, -1)$	k_x, k_y	k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, -1, -1)$	k_z, k_xk_y, k_yk_z	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, -1, +1, -1)$	k_y, k_z	k_x
60.428 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, -1)$	k_x, k_y, k_xk_z	k_z
60.429 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, -1)$	k_x, k_y, k_xk_z	k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, +1, -1)$	k_y, k_z	k_x
60.430 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,+1,-1)$	k_x, k_y, k_z	
60.431 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,+1,+1,-1)$	k_x, k_z, k_yk_z	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1,+1,-1,+1,-1,-1,-1)$	k_z, k_xk_y, k_yk_z	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,-1,+1,-1)$	$k_y, k_z, k_xk_yk_z, \ldots$	k_x
60.432 IV	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y, k_z, k_xk_y	k_x
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,-1)$	k_y, k_z, k_xk_y	k_x
61.435 III	Y	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_y, k_z	k_x
	S	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_y, k_z	k_x
61.437 III	U	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x, k_y, k_z	
	T	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
	S	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y, k_z	
61.438 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y, k_z, k_xk_y	k_x
	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,+1,+1,-1)$	k_x, k_z, k_yk_z	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,-1,-1,+1)$	k_x, k_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,-1)$	k_y, k_z, k_xk_y	k_x
61.439 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,+1,+1,-1)$	k_x, k_z, k_yk_z	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,-1,+1)$	k_x, k_z, k_yk_z	k_y
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,+1,-1)$	k_x, k_y, k_z	
61.440 IV	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	k_x, k_y, k_z	
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	k_x, k_y, k_z	
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,+1,-1)$	k_x, k_y, k_z	
62.443 III	Y	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_y, k_z	k_x
	Z	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_y, k_z	k_x
	U	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_y, k_z	k_x
	T	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_y, k_z	k_x
	S	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_y, k_z	k_x
	R	$C_{2v}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_y, k_z	k_x
62.444 III	U	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_z	k_y
	R	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_z	k_y
62.445 III	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y	k_z
	U	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y	k_z
62.449 III	U	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y, k_z	
	S	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y, k_z	
62.450 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y, k_z, k_xk_y	k_x
	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,+1,-1,+1)$	k_y, k_z, k_xk_z	k_x
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,+1,+1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,-1,+1,-1)$	$k_y, k_z, k_xk_yk_z, \ldots$	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,-1)$	k_y, k_z, k_xk_y	k_x
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1,+1,-1,+1,-1,-1,-1)$	k_z, k_xk_y, k_yk_z	k_x, k_y
62.451 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,-1,+1,-1,+1)$	k_x, k_y, k_xk_z	k_z
	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,+1,-1,+1)$	k_y, k_z, k_xk_z	k_x
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,+1,-1)$	k_y, k_z, k_xk_z	k_x
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1,+1,-1,-1,+1,-1,-1)$	k_z, k_xk_y, k_xk_z	k_x, k_y
62.452 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y, k_z, k_xk_y	k_x
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,-1,+1,-1,+1)$	k_x, k_y, k_xk_z	k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,+1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, -1)$	k_y, k_z, k_xk_y	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, -1, +1, -1)$	k_y, k_z	k_x
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, -1, -1, -1, -1)$	k_z, k_xk_y	k_x, k_y
62.453 IV	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, +1)$	k_x, k_y, k_xk_z	k_z
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, +1)$	$k_x, k_xk_y, k_xk_z, k_yk_z$	k_y, k_z
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, -1, +1, -1, -1)$	k_x, k_z, k_xk_y	k_y
62.454 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, -1)$	k_y, k_z, k_xk_y	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, -1)$	k_y, k_z, k_xk_y	k_x
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
62.455 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, +1)$	k_y, k_z, k_xk_z	k_x
	U	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	k_y, k_z, k_xk_z	k_x
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, -1)$	k_z, k_xk_y	k_x, k_y
62.456 IV	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	S	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
63.460 III	Z	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
	T	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
63.467 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1)$	k_m, k_n^3, k_z $(\boldsymbol{m} \perp \boldsymbol{n})$	
63.468 IV	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
64.472 III	Z	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
	T	$C_{2v}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_z	k_y
64.478 IV	S	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
64.479 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
65.488 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
65.490 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
66.497 III	Z	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
	T	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
66.499 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
67.508 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	S	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1)$	k_m, k_n^3, k_z $(\boldsymbol{m} \perp \boldsymbol{n})$	
67.510 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1)$	k_m, k_n^3, k_z $(\boldsymbol{m} \perp \boldsymbol{n})$	
68.517 III	Z	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
	T	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
68.518 IV	S	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
68.519 IV	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
	T	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
68.520 IV	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
70.531 III	Y	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	Z	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
70.532 IV	Y	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	k_x, k_y, k_z	
	Z	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	k_x, k_y, k_z	
71.538 IV	W	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
72.545 III	W	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
72.547 IV	S	$C_{2h}^2 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	W	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
73.553 IV	T	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
74.561 IV	T	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
84.56 IV	Z	$C_{4h} \times Z_2^T$	4	$(-1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$, $[k_zk_x, k_zk_y]$	
	A	$C_{4h} \times Z_2^T$	4	$(-1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$, $[k_zk_x, k_zk_y]$	
84.57 IV	Z	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
84.58 IV	Z	$C_{4h} \times Z_2^T$	4	$(-1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$, $[k_zk_x, k_zk_y]$	
	A	$C_{4h} \times Z_2^T$	4	$(-1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$, $[k_zk_x, k_zk_y]$	
85.64 IV	M	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$C_{4h} \times Z_2^T$	4	$(-1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$, $[k_zk_x, k_zk_y]$	
	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	X	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
85.65 IV	M	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
85.66 IV	M	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$C_{4h} \times Z_2^T$	4	$(-1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$, $[k_zk_x, k_zk_y]$	
	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
86.72 IV	M	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$C_{4h} \times Z_2^T$	4	$(-1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$, $[k_zk_x, k_zk_y]$	
	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	
	X	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
86.73 IV	M	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
86.74 IV	M	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$C_{4h} \times Z_2^T$	4	$(-1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$, $[k_zk_x, k_zk_y]$	
	R	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1)$	k_m, k_n^3, k_z ($\boldsymbol{m} \perp \boldsymbol{n}$)	

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
88.86 IV	Z	$C_{4h} \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	X	$C_{2h}^1 \times Z_2^T$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
123.348 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
123.349 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
123.350 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, +1)$	$[k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y, k_z$
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
124.356 III	Z	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
124.358 III	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
124.359 III	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
124.361 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, -1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, -1, -1)$	k_x, k_y, k_yk_z	k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
124.362 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, -1)$	$[k_x, k_y]$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, -1)$	k_x, k_y	k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
125.368 III	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
125.371 III	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
125.372 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	k_x, k_z, k_yk_z	k_y
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
125.373 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
125.374 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	A	$D_{4h}^1 \times Z_2^T$	8	$(-1, +1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, +1)$	k_x, k_z	k_y
126.380 III	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
126.382 III	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
126.383 III	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
126.384 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	k_y, k_z, k_xk_z	k_x
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
126.385 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	8	$(-1, -1, -1, -1, +1, +1, -1)$	$[k_x, k_y], k_z$	
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, -1)$	k_y, k_z, k_xk_y	k_x
126.386 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, -1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, +1, -1)$	$k_y, k_z, k_xk_yk_z, \ldots$	k_x
127.389 III	M	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	A	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
127.392 III	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
127.394 III	M	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
127.395 III	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
127.396 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, +1)$	$[k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y, k_z$
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, -1, -1)$	k_z, k_xk_y, k_yk_z	k_x, k_y
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
127.398 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, -1)$	k_z, k_xk_y	k_x, k_y
128.401 III	M	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	A	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
128.404 III	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
128.406 III	M	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	$[k_x, k_y]$	k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
128.407 III	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y],k_z$	
	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	$[k_x,k_y],k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	$[k_x,k_y],k_z$	
128.408 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,+1,+1)$	$k_xk_y,[k_zk_x,k_zk_y]$	k_x,k_y,k_z
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,-1,-1)$	$[k_x,k_y]$	k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,-1,-1)$	k_y,k_z,k_xk_y	k_x
128.409 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	$[k_x,k_y],k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	$[k_x,k_y],k_z$	
129.413 III	M	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y]$	k_z
	A	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y]$	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x,k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x,k_y	k_z
129.418 III	M	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y]$	k_z
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y]$	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x,k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x,k_y	k_z
129.420 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,-1,+1)$	$[k_x,k_y],k_xk_yk_z,\ldots$	k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,+1,+1)$	$k_z,[k_zk_x,k_zk_y]$	$k_x,k_{x\pm y},k_y$
	A	$D_{4h}^1 \times Z_2^T$	8	$(-1,+1,-1,-1,+1,-1,+1)$	$[k_x,k_y],k_z$	
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1,+1,-1,+1,-1,+1,-1)$	k_x,k_yk_z	k_y,k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,+1,-1)$	k_x,k_y,k_yk_z	k_z
129.421 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	$[k_x,k_y],k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	$[k_x,k_y],k_z$	
129.422 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	$[k_x,k_y],k_z$	
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,+1,+1)$	$k_z,[k_zk_x,k_zk_y]$	$k_x,k_{x\pm y},k_y$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,-1,+1)$	$k_z,k_x^2-k_y^2,[k_zk_x,k_zk_y]$	$k_{x\pm y}$
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,+1,+1,-1)$	k_x,k_z,k_yk_z	k_y
130.425 III	M	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y]$	k_z
	A	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y]$	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x,k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x,k_y	k_z
130.428 III	Z	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y],k_z$	
	A	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y],k_z$	
130.430 III	M	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x,k_y]$	k_z
	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	$[k_x,k_y],k_z$	
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	$[k_x,k_y]$	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x,k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x,k_y	k_z
130.431 III	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	$[k_x,k_y],k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	$[k_x,k_y],k_z$	
130.432 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,-1,+1)$	$[k_x,k_y],k_xk_yk_z,\ldots$	k_z
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1,+1,-1,-1,+1,+1,-1)$	$k_xk_y,[k_zk_x,k_zk_y]$	k_x,k_y,k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1,+1,-1,+1,-1,-1,+1)$	k_y,k_xk_z,k_yk_z	k_x,k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1,-1,-1,+1,-1,+1,-1)$	k_x,k_y,k_yk_z	k_z
130.433 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	$[k_x,k_y],k_z$	
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,-1)$	$[k_x,k_y],k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,+1,-1)$	$[k_x,k_y],k_z$	
130.434 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	$[k_x,k_y],k_z$	

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, +1)$	k_y, k_z, k_xk_z	k_x
131.442 III	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
131.443 III	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
131.444 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
131.445 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	8	$(-1, -1, -1, -1, +1, +1, -1)$	$[k_x, k_y], k_z$	
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
131.446 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, -1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, +1, +1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
132.452 III	Z	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
132.455 III	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
132.456 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
132.457 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, -1, -1)$	k_x, k_y, k_yk_z	k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
132.458 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
	A	$D_{4h}^1 \times Z_2^T$	8	$(-1, +1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, -1)$	k_x, k_y	k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, +1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
133.464 III	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
133.466 III	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
133.467 III	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
133.468 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	k_x, k_z, k_yk_z	k_y
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
133.469 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, -1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
133.470 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, -1)$	$[k_x, k_y]$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, -1, +1)$	k_x, k_z	k_y
134.476 III	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
134.479 III	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y, k_z	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_x, k_y, k_z	
134.480 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	k_y, k_z, k_xk_z	k_x
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_x, k_y, k_z	
134.481 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, -1, +1, -1)$	k_y, k_z, k_xk_y	k_x
134.482 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, +1)$	$[k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y, k_z$
	R	$D_{2h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, -1, +1, -1)$	$k_y, k_z, k_xk_yk_z, \ldots$	k_x
135.485 III	M	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	A	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
135.488 III	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
135.490 III	M	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	$[k_x, k_y]$	k_z
135.491 III	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	$[k_x, k_y], k_z$	
135.492 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, -1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, -1, -1)$	k_z, k_xk_y, k_yk_z	k_x, k_y
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
135.493 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	$[k_x, k_y], k_z$	
135.494 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, -1)$	k_z, k_xk_y	k_x, k_y
136.497 III	M	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	A	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
136.500 III	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
136.502 III	M	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
136.503 III	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
136.504 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
	A	$D_{4h}^1 \times Z_2^T$	8	$(-1, +1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, -1, -1)$	k_y, k_z, k_xk_y	k_x
136.505 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
136.506 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
137.509 III	M	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	A	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
137.514 III	M	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	$[k_x, k_y]$	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
137.515 III	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
137.516 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, -1, -1)$	$[k_x, k_y]$	k_z
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, +1, -1)$	k_x, k_yk_z	k_y, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, +1, -1)$	k_x, k_y, k_yk_z	k_z
137.517 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	$[k_x, k_y], k_z$	
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, -1)$	$[k_x, k_y], k_z$	
137.518 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_z, k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, +1, -1)$	k_x, k_z, k_yk_z	k_y
138.521 III	M	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	A	$C_{4v} \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
138.524 III	Z	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
138.526 III	M	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	A	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y]$	k_z
	R	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
	X	$C_{2v}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	k_x, k_y	k_z
138.527 III	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	A	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
138.528 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, -1, +1, +1, +1)$	$[k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y, k_z$
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, +1, -1, +1, -1, -1, +1)$	k_y, k_xk_z, k_yk_z	k_x, k_z
	X	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, -1, +1, -1)$	k_x, k_y, k_yk_z	k_z
138.529 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
138.530 IV	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_y], k_z$	
	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_z, k_x^2 - k_y^2, [k_zk_x, k_zk_y]$	$k_{x\pm y}$
	A	$D_{4h}^1 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, +1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm y}, k_y$
	R	$D_{2h}^1 \times Z_2^T$	4	$(+1, -1, -1, +1, +1, -1, +1)$	k_y, k_z, k_xk_z	k_x
139.540 IV	P	$D_{2d}^1 \times Z_2^T$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
140.546 III	P	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
140.549 III	P	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_y, k_z	
141.558 III	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	X	$D_2^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_{x-y}, k_{x+y}, k_z	
141.559 III	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	X	$D_2^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_{x-y}, k_{x+y}, k_z	
141.560 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	$[k_x, k_y], k_z$	
	X	$D_{2h}^2 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_{x-y}, k_{x+y}, k_z	
	P	$D_{2d}^1 \times Z_2^{\tilde{T}}$	2|4	$(+1, -1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$	
142.566 III	P	$D_{2d}^1 \times Z_2^{\tilde{T}}$	2|4	$(+1, -1, -1, +1)$	$k_z, k_x^2 - k_y^2, k_xk_y$	
142.568 III	Z	$D_{2d}^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	X	$D_2^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_{x-y}, k_{x+y}, k_z	
142.569 III	Z	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_y], k_z$	
	X	$D_2^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_{x-y}, k_{x+y}, k_z	
142.570 IV	Z	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, +1, -1)$	$[k_x, k_y], k_z$	
	X	$D_{2h}^2 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	k_{x-y}, k_{x+y}, k_z	
162.78 IV	A	$D_{3d}^1 \times Z_2^T$	2|4	$(+1, +1, -1, +1)$	$k_z, [k_x^2 - k_y^2, 2k_xk_y]$	
163.82 III	A	$D_3^1 \times Z_2^{\tilde{T}}$	2|4	$(-1, -1)$	$[k_x, k_y], k_z$	
164.90 IV	A	$D_{3d}^2 \times Z_2^T$	2|4	$(+1, +1, -1, +1)$	$k_z, [k_x^2 - k_y^2, 2k_xk_y]$	
	H	$D_3^2 \times Z_2^{\tilde{T}}$	2|4	$(-1, -1)$	$[k_x, k_y], k_z$	
165.94 III	A	$D_3^2 \times Z_2^{\tilde{T}}$	2|4	$(-1, -1)$	$[k_x, k_y], k_z$	
	H	$D_3^2 \times Z_2^{\tilde{T}}$	2|4	$(-1, -1)$	$[k_x, k_y], k_z$	
166.102 IV	Z	$D_{3d}^1 \times Z_2^T$	2|4	$(+1, +1, -1, +1)$	$k_z, [k_x^2 - k_y^2, 2k_xk_y]$	
167.106 III	Z	$D_3^1 \times Z_2^{\tilde{T}}$	2|4	$(-1, -1)$	$[k_x, k_y], k_z$	
176.148 IV	A	$C_{6h} \times Z_2^T$	2|4	$(-1, +1, -1, +1)$	$k_z, [k_x^2, k_y^2]$	

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
191.242 IV	L	$D_{2h}^3 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,+1,+1)$	$k_z, k_xk_y, k_xk_z, k_yk_z$	k_x, k_y
	H	$D_{3h}^2 \times Z_2^{\tilde{T}}$	4_1	$(-1,-1,-1,+1)$	k_z	$k_y, k_{\sqrt{3}x\pm y}$
			4_2	$(-1,-1,-1,+1)$	$k_z, [k_zk_x, k_zk_y]$	$k_y, k_{\sqrt{3}x\pm y}$
	A	$D_{6h} \times Z_2^T$	4_1	$(-1,+1,-1,+1,+1,+1,+1)$	k_z	$k_x, k_y, k_{x\pm\sqrt{3}y}, k_{\sqrt{3}x\pm y}$
			$4_{2,3}$	$(-1,+1,-1,+1,+1,+1,+1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_y, k_{x\pm\sqrt{3}y}, k_{\sqrt{3}x\pm y}$
192.246 III	A	$D_{3h}^1 \times Z_2^{\tilde{T}}$	2|4	$(+1,-1,+1,-1)$	$[k_x, k_y], k_z$	
192.247 III	A	$D_{3h}^2 \times Z_2^{\tilde{T}}$	2|4	$(+1,-1,+1,+1)$	$[k_x, k_y], k_z$	
	H	$D_{3h}^2 \times Z_2^{\tilde{T}}$	2|4	$(+1,-1,+1,+1)$	$[k_x, k_y], k_z$	
192.251 III	L	$D_2^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
	A	$D_6 \times Z_2^{\tilde{T}}$	$4_{1,2}$	$(-1,-1,+1,-1)$	$[k_x, k_y], k_z$	
			4_3	$(-1,-1,+1,-1)$	$k_z, k_x^3-3k_xk_y^2, k_y^3-3k_yk_x^2, \ldots$	
	H	$D_3^2 \times Z_2^{\tilde{T}}$	2|4	$(-1,-1)$	$[k_x, k_y], k_z$	
193.257 III	L	$C_{2v}^5 \times Z_2^{\tilde{T}}$	4	$(-1,-1,+1,-1)$	k_x, k_z	k_y
	A	$D_{3h}^2 \times Z_2^{\tilde{T}}$	4_1	$(-1,-1,-1,+1)$	k_z	$k_y, k_{\sqrt{3}x\pm y}$
			4_2	$(-1,-1,-1,+1)$	$k_z, [k_zk_x, k_zk_y]$	$k_y, k_{\sqrt{3}x\pm y}$
	H	$D_{3h}^2 \times Z_2^{\tilde{T}}$	4_1	$(-1,-1,-1,+1)$	k_z	$k_y, k_{\sqrt{3}x\pm y}$
			4_2	$(-1,-1,-1,+1)$	$k_z, [k_zk_x, k_zk_y]$	$k_y, k_{\sqrt{3}x\pm y}$
193.261 III	A	$D_6 \times Z_2^{\tilde{T}}$	2|4	$(+1,-1,+1,+1)$	$k_z, [k_x^2-k_y^2, 2k_xk_y], k_x^3-3k_xk_y^2, \ldots$	
	H	$D_3^2 \times Z_2^{\tilde{T}}$	2|4	$(-1,-1)$	$[k_x, k_y], k_z$	
193.262 IV	A	$D_{6h} \times Z_2^T$	2|4	$(+1,+1,-1,+1,+1,+1,-1)$	$k_z, [k_x^2-k_y^2, 2k_xk_y], k_y^3-3k_yk_x^2, \ldots$	
194.266 III	L	$C_{2v}^4 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_y, k_z	k_x
	A	$D_{3h}^1 \times Z_2^{\tilde{T}}$	4_1	$(-1,-1,-1,-1)$	k_z	$k_x, k_{x\pm\sqrt{3}y}$
			4_2	$(-1,-1,-1,-1)$	$k_z, [k_zk_x, k_zk_y]$	$k_x, k_{x\pm\sqrt{3}y}$
194.271 III	A	$D_6 \times Z_2^{\tilde{T}}$	2|4	$(+1,-1,+1,-1)$	$k_z, [k_x^2-k_y^2, 2k_xk_y], k_y^3-3k_yk_x^2, \ldots$	
194.272 IV	A	$D_{6h} \times Z_2^T$	2|4	$(+1,+1,-1,+1,+1,-1,+1)$	$k_z, [k_x^2-k_y^2, 2k_xk_y], k_x^3-3k_xk_y^2, \ldots$	
	H	$D_{3h}^2 \times Z_2^{\tilde{T}}$	2|4	$(+1,-1,+1,+1)$	$[k_x, k_y], k_z$	
200.16 III	Γ	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
	R	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
200.17 IV	Γ	$T_h \times Z_2^T$	2|4	$(-1,-1,-1)$	$[k_xk_y, k_xk_z, k_yk_z]$	
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,+1,-1,+1,-1,+1,+1)$	$k_y, k_xk_y, k_xk_z, k_yk_z$	k_x, k_z
	M	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,+1,+1)$	k_xk_y, k_xk_z, k_yk_z	k_x, k_y, k_z
	R	$T_h \times Z_2^T$	4	$(-1,+1,-1)$	$[k_xk_y, k_xk_z, k_yk_z]$	k_x, k_y, k_z
201.20 III	Γ	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y, k_z	
	M	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	k_x, k_y, k_z	
	R	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
201.21 IV	Γ	$T_h \times Z_2^T$	2|4	$(-1,-1,-1)$	$[k_xk_y, k_xk_z, k_yk_z]$	
	M	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,-1,-1,-1)$	$k_x, k_y, k_xk_yk_z, \ldots$	k_z
	R	$T_h \times Z_2^T$	4	$(-1,+1,-1)$	$[k_xk_y, k_xk_z, k_yk_z]$	k_x, k_y, k_z
202.24 III	Γ	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
202.25 IV	Γ	$T_h \times Z_2^T$	2|4	$(-1,-1,-1)$	$[k_xk_y, k_xk_z, k_yk_z]$	
203.28 III	Γ	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
	X	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y, k_z	

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
203.29 IV	Γ	$T_h \times Z_2^T$	2|4	$(-1,-1,-1)$	$[k_xk_y, k_xk_z, k_yk_z]$	
	X	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,-1,+1)$	k_x, k_y, k_z	
204.32 III	Γ	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
	H	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
	P	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
205.35 III	Γ	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
	M	$D_2^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	k_x, k_y, k_z	
	R	$T \times Z_2^{\tilde{T}}$	2|6	$(-1,-1)$	$[k_x, k_y, k_z]$	
205.36 IV	Γ	$T_h \times Z_2^T$	2|4	$(-1,-1,-1)$	$[k_xk_y, k_xk_z, k_yk_z]$	
	M	$D_{2h}^1 \times Z_2^T$	4	$(-1,-1,-1,+1,+1,+1,-1)$	k_x, k_y, k_z	
	R	$T_h \times Z_2^T$	2|6	$(+1,+1,-1)$	$[k_x, k_y, k_z]$	
206.39 III	Γ	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
	H	$T \times Z_2^{\tilde{T}}$	2|4	$(-1,+1)$	$[k_x, k_y, k_z]$	
	P	$T \times Z_2^{\tilde{T}}$	2|6	$(-1,-1)$	$[k_x, k_y, k_z]$	
221.94 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_x, k_y, k_z]$	
	R	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_x, k_y, k_z]$	
221.96 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2-k_x^2-k_y^2, k_x^2-k_y^2]$	
	R	$O \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2-k_x^2-k_y^2, k_x^2-k_y^2]$	
221.97 IV	Γ	$O_h \times Z_2^T$	2|4	$(-1,-1,-1,+1,+1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2-k_x^2-k_y^2, k_x^2-k_y^2]$	
	X	$D_{4h}^2 \times Z_2^T$	4	$(-1,+1,-1,+1,+1,+1,+1)$	$k_y, [k_yk_x, k_yk_z]$	$k_x, k_{x\pm z}, k_z$
	M	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,+1,+1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	R	$O_h \times Z_2^T$	4|8	$(-1,+1,-1,+1,+1)$	$[k_x, k_y, k_z]$	
			$4\|4_{1,2}$	$(-1,+1,-1,+1,+1)$	$k_xk_yk_z, \ldots$	$k_x, k_y, k_z, k_{x\pm y}, k_{x\pm z}, k_{y\pm z}$
222.100 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_x, k_y, k_z]$	
	X	$D_{2d}^3 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x, k_z], k_y$	
	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x, k_y], k_z$	
	R	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_x, k_y, k_z]$	
222.102 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2-k_x^2-k_y^2, k_x^2-k_y^2]$	
	X	$D_4^2 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,-1)$	$[k_x, k_z], k_y$	
	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1,-1,-1,+1)$	$[k_x, k_y], k_z$	
	R	$O \times Z_2^{\tilde{T}}$	4|4	$(-1,+1,-1)$	$[k_x, k_y, k_z]$	
			4|8	$(-1,+1,-1)$	$[k_x, k_y, k_z]$	
222.103 IV	Γ	$O_h \times Z_2^T$	2|4	$(-1,-1,-1,+1,+1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2-k_x^2-k_y^2, k_x^2-k_y^2]$	
	M	$D_{4h}^1 \times Z_2^T$	4	$(-1,-1,-1,-1,+1,-1,+1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	R	$O_h \times Z_2^T$	$4_{1,2}$	$(-1,+1,-1,+1,-1)$	$[k_xk_y, k_xk_z, k_yk_z]$	k_x, k_y, k_z
			4_3	$(-1,+1,-1,+1,-1)$	$[k_xk_y, k_xk_z, k_yk_z], k_xk_yk_z, \ldots$	k_x, k_y, k_z
223.106 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_x, k_y, k_z]$	
	R	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_x, k_y, k_z]$	
223.108 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1,+1,+1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2-k_x^2-k_y^2, k_x^2-k_y^2]$	

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
	X	$D_4^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$[k_x, k_z], k_y$	
	R	$O \times Z_2^{\tilde{T}}$	4|4	$(-1, +1, -1)$	$[k_x, k_y, k_z]$	
			4|8	$(-1, +1, -1)$	$[k_x, k_y, k_z]$	
223.109 IV	Γ	$O_h \times Z_2^T$	2|4	$(-1, -1, -1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	X	$D_{4h}^2 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, +1, -1)$	$k_y, k_xk_z, [k_yk_x, k_yk_z]$	k_x, k_z
	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, +1, +1)$	$k_xk_y, [k_zk_x, k_zk_y]$	k_x, k_y, k_z
	R	$O_h \times Z_2^T$	$4_{1,2}$	$(-1, +1, -1, +1, -1)$	$[k_xk_y, k_xk_z, k_yk_z]$	k_x, k_y, k_z
			4_3	$(-1, +1, -1, +1, -1)$	$[k_xk_y, k_xk_z, k_yk_z], k_xk_yk_z, \ldots$	k_x, k_y, k_z
224.112 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
	X	$D_{2d}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_z], k_y$	
	M	$D_{2d}^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
224.114 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	X	$D_4^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_z], k_y$	
	M	$D_4^1 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_y], k_z$	
	R	$O \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
224.115 IV	Γ	$O_h \times Z_2^T$	2|4	$(-1, -1, -1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	X	$D_{4h}^2 \times Z_2^T$	4	$(-1, +1, -1, +1, +1, -1, +1)$	$k_y, k_x^2 - k_z^2, [k_yk_x, k_yk_z]$	$k_{x\pm z}$
	M	$D_{4h}^1 \times Z_2^T$	4	$(-1, -1, -1, -1, +1, -1, +1)$	$[k_x, k_y], k_xk_yk_z, \ldots$	k_z
	R	$O_h \times Z_2^T$	4|8	$(-1, +1, -1, +1, +1)$	$[k_x, k_y, k_z]$	
			$4\|4_{1,2}$	$(-1, +1, -1, +1, +1)$	$k_xk_yk_z, \ldots$	$k_x, k_y, k_z, k_{x\pm y}, k_{x\pm z}, k_{y\pm z}$
225.118 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
225.120 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
225.121 IV	Γ	$O_h \times Z_2^T$	2|4	$(-1, -1, -1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	L	$D_{3d}^3 \times Z_2^T$	2|4	$(+1, +1, -1, +1)$	$k_{x+y+z}, (k_{x+y+z}^{\perp})^2$	
	W	$D_{2d}^4 \times Z_2^{\tilde{T}}$	4	$(-1, -1, +1, -1)$	$k_x, [k_y, k_z]$	
226.124 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
226.126 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	L	$D_3^3 \times Z_2^{\tilde{T}}$	2|4	$(-1, -1)$	$k_{x+y+z}, k_{x+y+z}^{\perp}$	
	W	$D_2^4 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, -1)$	k_x, k_{y-z}, k_{y+z}	
226.127 IV	Γ	$O_h \times Z_2^T$	2|4	$(-1, -1, -1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
227.130 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
	X	$D_{2d}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_z], k_y$	
227.132 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	X	$D_4^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_z], k_y$	

TABLE I. (*Continued.*)

Shubnikov space group	HSP	$G_0(\boldsymbol{k})$	dim	l.c.	disp.	n.l.
227.133 IV	Γ	$O_h \times Z_2^T$	2|4	$(-1, -1, -1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	X	$D_{4h}^2 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_z], k_y$	
	L	$D_{3d}^3 \times Z_2^T$	2|4	$(+1, +1, -1, +1)$	$k_{x+y+z}, (k_{x+y+z}^{\perp})^2$	
	W	$D_{2d}^4 \times Z_2^{\tilde{T}}$	2|4	$(+1, -1, +1, -1)$	$k_x, k_y^2 - k_z^2, k_yk_z$	
228.136 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
	X	$D_{2d}^3 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_z], k_y$	
228.138 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	X	$D_4^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	$[k_x, k_z], k_y$	
	L	$D_3^3 \times Z_2^{\tilde{T}}$	2|4	$(-1, -1)$	$k_{x+y+z}, k_{x+y+z}^{\perp}$	
228.139 IV	Γ	$O_h \times Z_2^T$	2|4	$(-1, -1, -1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	X	$D_{4h}^2 \times Z_2^T$	4	$(-1, -1, -1, +1, +1, -1, +1)$	$[k_x, k_z], k_y$	
229.142 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
	H	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
	P	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
229.144 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	H	$O \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	P	$T \times Z_2^{\tilde{T}}$	2|4	$(-1, +1)$	$[k_x, k_y, k_z]$	
230.147 III	Γ	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
	H	$T_d \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_x, k_y, k_z]$	
	P	$T_d \times Z_2^{\tilde{T}}$	2|6	$(-1, -1, +1)$	$[k_x, k_y, k_z]$	
230.149 III	Γ	$O \times Z_2^{\tilde{T}}$	2|4	$(-1, +1, +1)$	$[k_xk_y, k_xk_z, k_yk_z]$, $[2k_z^2 - k_x^2 - k_y^2, k_x^2 - k_y^2]$	
	N	$D_2^2 \times Z_2^{\tilde{T}}$	4	$(-1, -1, -1, +1)$	k_{x-y}, k_{x+y}, k_z	
	H	$O \times Z_2^{\tilde{T}}$	4|4	$(-1, +1, -1)$	$[k_x, k_y, k_z]$	
			4|8	$(-1, +1, -1)$	$[k_x, k_y, k_z]$	
	P	$T \times Z_2^{\tilde{T}}$	2|6	$(-1, -1)$	$[k_x, k_y, k_z]$	

For bosonic quasiparticles (such as the magnons) with integer spin, or for fermionic quasi-particles where spin-orbital coupling is very weak, the band structure is characterized by projective Rep of $G_0(\boldsymbol{k})$ with the factor system $\omega_{2b}(g_1, g_2)$ provided in (4).

However, for fermionic particles with half-odd-integer spin, an extra factor system $\omega_2^{(\frac{1}{2})}(g_1, g_2)$ is contributed from the spin rotation owing to spin-orbit coupling. The spin-orbit coupling is always present for the itinerant electron in magnetic materials because the Zeeman coupling term

$$H_{\text{Zeeman}} = \mu_0 \sum_i \hat{\boldsymbol{S}}_i \cdot \boldsymbol{m}_i \tag{6}$$

(where $\hat{\boldsymbol{S}}_i$ is the spin operator of the fermions and $\boldsymbol{m}_i$ is the local magnetic moment of the material) locks the point-group rotations with the corresponding spin rotations and hence defines a spin-orbit coupling.

The factor system $\omega_2^{(\frac{1}{2})}(g_1, g_2)$ can be obtained from the double valued Reps of the little cogroup $G_0(\boldsymbol{k})$. The simplest double valued Rep is the one carried by spin-1/2. Any rotation operation $R_{\boldsymbol{n}}(\theta)$ of angle θ along the direction $\boldsymbol{n}$ is represented as $D^{(\frac{1}{2})}(R_n(\theta)) = e^{-i\frac{\theta}{2}\sigma\cdot\boldsymbol{n}}$, the inversion $\mathcal{I}$ is represented as $D^{(1/2)}(\mathcal{I}) = I$, and the time reversal is represented as $i\sigma_y K$. Then $\omega_2^{(1/2)}(g_1, g_2)$ appears in the multiplication rule

$$\begin{aligned} D^{(\frac{1}{2})}(g_1)K_{s(g_1)}D^{(\frac{1}{2})}(g_2)K_{s(g_2)} \\ = \omega_2^{(\frac{1}{2})}(g_1, g_2)D^{(\frac{1}{2})}(g_1g_2)K_{s(g_1g_2)}. \end{aligned} \tag{7}$$

Another way to obtain $\omega_2^{(1/2)}(g_1, g_2)$ is to solve the cocycle equations (A5) and obtain the representative solutions for every class, then select out the right class of solution by verifying the values of the invariants (given in Table II) such that they are the same as those of the double valued Reps. For instance, in a double valued Rep, $\chi_S = \frac{\omega_2(C_{2x},C_{2y})}{\omega_2(C_{2y},C_{2x})} = -1$, $\chi_{\tilde{T}} = \omega_2(\tilde{T},\tilde{T}) = -1$ and so on.

Combining with the factor system from fractional translation, the total factor system for fermions is given by [46]

$$\omega_{2f}(g_1, g_2) = \omega_2^{(\frac{1}{2})}(g_1, g_2)\omega_{2b}(g_1, g_2). \tag{8}$$

The factor systems $\omega_{2b}(g_1, g_2)$, $\omega_2^{(\frac{1}{2})}(g_1, g_2)$, $\omega_{2f}(g_1, g_2)$ generally belong to different classes of projective Reps of the little cogroup $G_0(\boldsymbol{k})$, in the sense that they cannot be transformed into each other by the gauge transformation (3). The gauge transformations are redundant degrees of freedom because the physical properties are determined by the gauge equivalent classes and the corresponding irreducible Reps.

It turns out that all of the classes of projective Reps of $G_0(\boldsymbol{k})$ are classified by the second group cohomology $\mathcal{H}^2(G_0(\boldsymbol{k}), U(1))$ and are characterized by several gauge invariants. To obtain the classification and Rep matrices of the $G_0(\boldsymbol{k})$ at the momentum $\boldsymbol{k}$, we explicitly calculate the second group cohomology $\mathcal{H}^2(G_0(\boldsymbol{k}), U(1))$, provide all the gauge invariants and the corresponding factor system for each class. From every class of factor system, we construct the regular projective Rep and then obtain all the inequivalent IPReps [47]. The invariants are provided in Table II and the IPReps at the HSPs of the BZ of monoclinic, orthorhombic, tetragonal, trigonal, hexagonal, and cubic lattices are given in Tables III–VI.

From the gauge invariants, we can easily tell the classification label of the factor system given by (4) and (8). As listed in Table I, we provide the lowest dimension of IPReps of $G_0(\boldsymbol{k})$ at the HSPs for fermionic particles, which is related to the degrees of degeneracy in the energy bands of electrons at these points. Next, from the Rep matrices, we can judge the dispersion around the degeneracy points/lines from $\boldsymbol{k}\cdot\boldsymbol{p}$ theory. The results are also listed in Table I, and the method is discussed in the next section.

III. DISPERSION: CRITERIA FOR DIRAC CONES, NODAL LINES, AND OTHERS

Since we only consider type-III and type-IV Shubnikov magnetic space groups containing the symmetry operation $\{\tilde{T}|\boldsymbol{\tau}_{\tilde{T}}\}$, the little cogroups $G_0(\boldsymbol{k})$ always contain $\tilde{T}$. [Since $G_0(\boldsymbol{k})$ is the quotient group of magnetic little group $\mathcal{M}(\boldsymbol{k})$ with respect to the translation group, all the elements of $G_0(\boldsymbol{k})$ have no fractional translation.] Obviously, $\tilde{T}$ commutes with all the other group elements in $G_0(\boldsymbol{k})$, therefore $G_0(\boldsymbol{k})$ has the following structure

$$G_0(\boldsymbol{k}) = H \times Z_2^{\tilde{T}}, \tag{9}$$

with H a unitary point group and $Z_2^{\tilde{T}} = \{E, \tilde{T}\}$.

We assume that the little cogroup $G_0(\boldsymbol{k})$ at momentum $\boldsymbol{k}$ supports high-dimensional ($d \geqslant 4$) IPReps whose Rep matrices are known. In this section, we provide the method to judge if the dispersion around the point $\boldsymbol{k}$ is linear or quadratic, and if the degeneracy is stable in a HSL. Thus we can know the symmetry groups that can host symmetry-protected Dirac cones, quadratic band touching nodal points, nodal lines, and other dispersion relations.

A. Nodal points with linear or higher-order dispersions

Supposing that at a HSP $\boldsymbol{k}$ the energy eigenstates carry a d-dimensional ($d \geqslant 4$) IPRep $M(G_0(\boldsymbol{k}))$ of the little cogroup $G_0(\boldsymbol{k})$, and that $\boldsymbol{k}$ is a touching point of two energy bands. We first discuss the criteria for a Dirac-type linear dispersion.

Following the spirit of $\boldsymbol{k}\cdot\boldsymbol{p}$ theory, it is sufficient to consider the bands touching at the HSP $\boldsymbol{k}$. We write the fermion bases of the d-dimensional IPRep as $|\phi_{\boldsymbol{k}}^\alpha\rangle = (\psi_{\boldsymbol{k}}^\alpha)^\dagger|\text{vacumn}\rangle$, $\alpha = 1, 2, ..., d$, then for $g \in G_0(\boldsymbol{k})$ we have

$$\hat{g}|\phi_{\boldsymbol{k}}^\alpha\rangle = \sum_{\beta=1}^{d} |\phi_{\boldsymbol{k}}^\beta\rangle M(g)_{\beta\alpha} K_{s(g)}, \tag{10}$$

or equivalently

$$\hat{g}(\psi_{\boldsymbol{k}}^\dagger)\hat{g}^{-1} = \psi_{\boldsymbol{k}}^\dagger M(g) K_{s(g)}, \tag{11}$$

$$\hat{g}\psi_{\boldsymbol{k}}\hat{g}^{-1} = K_{s(g)} M(g)^\dagger \psi_{\boldsymbol{k}}, \tag{12}$$

here the group element g is treated as an operator $\hat{g}$ (see Appendix A). If the point $\boldsymbol{k}$ is indeed a Dirac cone, then at the vicinity of $\boldsymbol{k}$ the Hamiltonian should be in form of:

$$H_{\boldsymbol{k}+\delta\boldsymbol{k}} = \psi_{\boldsymbol{k}+\delta\boldsymbol{k}}^\dagger(\delta\boldsymbol{k}\cdot\Gamma)\psi_{\boldsymbol{k}+\delta\boldsymbol{k}}, \tag{13}$$

where Γ_m, $m = x, y, z$ are three $d \times d$ Hermitian matrices with

$$\Gamma_m^\dagger = \Gamma_m. \tag{14}$$

When $\delta\boldsymbol{k}$ is small enough, relations similar to (11) and (12) hold for $\psi_{\boldsymbol{k}+\delta\boldsymbol{k}}^\dagger$ and $\psi_{\boldsymbol{k}+\delta\boldsymbol{k}}$ with

$$\hat{g}(\psi_{\boldsymbol{k}+\delta\boldsymbol{k}}^\dagger)\hat{g}^{-1} = \psi_{\boldsymbol{k}+\hat{g}\delta\boldsymbol{k}}^\dagger M(g) K_{s(g)}, \tag{15}$$

$$\hat{g}\psi_{\boldsymbol{k}+\delta\boldsymbol{k}}\hat{g}^{-1} = K_{s(g)} M(g)^\dagger \psi_{\boldsymbol{k}+\hat{g}\delta\boldsymbol{k}}. \tag{16}$$

At the vicinity of $\boldsymbol{k}$, the total Hamiltonian preserves the $G_0(\boldsymbol{k})$ symmetry, therefore,

$$\hat{g}_1\left(\sum_{\delta\boldsymbol{k}} H_{\boldsymbol{k}+\delta\boldsymbol{k}}\right)\hat{g}_1^{-1} = \sum_{\delta\boldsymbol{k}} H_{\boldsymbol{k}+\delta\boldsymbol{k}} \tag{17}$$

for all $g_1 \in G_0(\boldsymbol{k})$.

Now we analyze the condition under which the leading order perturbation is given by (13). Notice that $\delta\boldsymbol{k}$ varies as a vector under the action of $h \in H$, i.e.,

$$h\delta\boldsymbol{k}_m = \sum_n D_{nm}^{(\boldsymbol{v})}(h)\delta\boldsymbol{k}_n, \; h \in H, \tag{18}$$

where H is the halving unitary subgroup of $G_0(\boldsymbol{k})$, $D_{nm}^{(\boldsymbol{v})}(h)$ are linear combination coefficients, which are matrix elements of the vector Reps of H. Moreover $\delta\boldsymbol{k}_m$ is invariant under action of $\tilde{T} = \mathcal{I}T$

$$\tilde{T}\delta\boldsymbol{k}_m = \delta\boldsymbol{k}_m. \tag{19}$$

Here we adopt the orthonormal bases $[\boldsymbol{b}_x, \boldsymbol{b}_y, \boldsymbol{b}_z]$ in momentum space such that $\delta\boldsymbol{k}$ has the components $(\delta\boldsymbol{k}_x, \delta\boldsymbol{k}_y, \delta\boldsymbol{k}_z)^T$.

To ensure that the total Hamiltonian is symmetric under $G_0(\boldsymbol{k})$, Γ_m should vary in the same way as $\delta\boldsymbol{k}$ under action of $G_0(\boldsymbol{k})$,

$$M(h)\Gamma_m M(h)^\dagger = \sum_n D^{(\boldsymbol{v})}_{nm}(h)\Gamma_n,$$
$$M(\tilde{T})K\Gamma_m K M(\tilde{T})^\dagger = \Gamma_m. \tag{20}$$

The second equation is equivalent to

$$M(\tilde{T})\Gamma_m^* M(\tilde{T})^\dagger = \Gamma_m. \tag{21}$$

If there exist matrices $\Gamma_{x,y,z}$ satisfying the conditions (14), (20), and (21), then the Hamiltonian (13) yields a linear dispersion. Therefore, the existence of linear dispersion along m direction is equivalent to the existence of the matrix Γ_m satisfying above conditions.

From group theory, the condition (20) requires that the direct product Rep $M(h)\otimes M^*(h)$ of the halving unitary subgroup H contains the vector Rep $D^{(v)}(h)$. Furthermore, the hermiticity condition (14) and the $\tilde{T}$ condition (21) together require that the matrix $\Gamma_m, m = x, y, z$ satisfies the skew-symmetry condition $\tilde{\Gamma}_m^T = -\tilde{\Gamma}_m$ with $\tilde{\Gamma}_m = \Gamma_m M^T(\tilde{T})$ (see [48] for detailed derivation). All of the above conditions can be checked by calculating a single quantity

$$a_{\boldsymbol{k}} = \frac{1}{2|H|}\sum_{h\in H}[|\chi(h)|^2 + \omega_2(\tilde{T}h,\tilde{T}h)\chi((\tilde{T}h)^2)]\chi^{(\boldsymbol{v})*}(h)$$
$$= \frac{1}{2|H|}\sum_{h\in H}[|\chi(h)|^2 + \mathrm{Tr}[M(\tilde{T}h)M^*(\tilde{T}h)]]\chi^{(\boldsymbol{v})*}(h), \tag{22}$$

where $a_{\boldsymbol{k}}$ is the number of independent set of matrices $\Gamma_{x,y,z}$ satisfying the conditions (14), (20), (21), and $\chi^{(v)}(h) = \mathrm{Tr}[D^{(v)}(h)]$ is the character of vector Rep of $D^{(v)}(h), h\in H$. If $a_{\boldsymbol{k}}$ is a nonzero integer, then the matrices $\Gamma_{x,y,z}$ can be found and the dispersion is linear along all directions, otherwise the dispersion maybe quadratic.

Above we have assumed that the vector Rep $D^{(\boldsymbol{v})}(H)$ of H is irreducible and hence $\Gamma_{x,y,z}$ can be transformed into each other by the action of the little cogroup $G_0(\boldsymbol{k})$. For most point groups, $D^{(v)}(H)$ is reducible (unless H is one of the high-symmetry groups T, T_h, T_d, O, O_h). In that case, linear dispersion may only exist along special directions and we need to check them separately. Suppose a linear Rep (μ) is included in the vector Rep, then the linear dispersion along the directions of the corresponding bases can be judged from

$$a_\mu = \frac{1}{2|H|}\sum_{h\in H}[|\chi(h)|^2 + \mathrm{Tr}[M(\tilde{T}h)M^*(\tilde{T}h)]]\chi^{(\mu)*}(h). \tag{23}$$

For instance, the vector Rep of $H = D_{4h}$ is reduced into $A_{2u}\oplus E_u$, and accordingly the vector $\delta\boldsymbol{k}$ is separated into (k_z) and $(k_x, k_y)^T$. Therefore, we can judge the linear dispersion along k_z direction by calculating

$$a_z = \frac{1}{2|H|}\sum_{h\in H}\left[|\chi(h)|^2 + \mathrm{Tr}[M(\tilde{T}h)M^*(\tilde{T}h)]\right]\chi^{(A_{2u})*}(h), \tag{24}$$

and judge the linear-dispersion along k_x, k_y directions by calculating

$$a_{xy} = \frac{1}{2|H|}\sum_{h\in H}[|\chi(h)|^2 + \mathrm{Tr}[M(\tilde{T}h)M^*(\tilde{T}h)]]\chi^{(E_u)*}(h). \tag{25}$$

Since E_u is irreducible, if $a_{xy}\neq 0$ then the dispersion in the (k_x, k_y) plane is linear. If both a_{xy} and a_z are nonzero, then the dispersion is linear in all directions.

Above discussion can be easily generalized to judge the existence of quadratic or higher-order dispersions. As the linear dispersion terms correspond to vector Reps of halving unitary subgroup $H\subset G_0(\boldsymbol{k})$, quadratic or higher-order dispersion terms carry other linear Reps of H. The $\chi^{(v)}(h)$ in (22) should be replaced by character of other linear Reps of H.

In Table I we give the dispersion terms, which are not higher than third order at the vicinity of HSP. We also provide the directions of nodal lines in the BZ. The criterion for the existence of nodal lines crossing a HSP is discussed below.

B. Nodal-line dispersions

Now we discuss possible cases where a HSL has a nodal-line dispersion, namely, the band is always 4-fold degenerate along this HSL (except for some special points where the degeneracy may be higher than 4). In these cases, the little cogroups of the HSLs are $C_{nv}\times Z_2^{\tilde{T}}$, which are included in Table II.

Without loss of generality, we assume that HSL is along k_z direction. Obviously $[\boldsymbol{b}_z]$ carries the identity Rep of C_{nv} and of $Z_2^{\tilde{T}}$ (and hence of $C_{nv}\times Z_2^{\tilde{T}}$). In the following we start with a HSP whose little cogroup is $G_0(\boldsymbol{k}) = H\times Z_2^{\tilde{T}}$ with $H\supseteq C_{nv}$, and judge if the k_z-line crossing it forms a nodal line or not.

Case I: the little cogroup of a HSP is the same as that of the HSL crossing it, namely, $H = C_{nv}$ and $G_0(\boldsymbol{k}) = C_{nv}\times Z_2^{\tilde{T}}$. Therefore, the high-dimensional IPReps at the HSP remains irreducible along the HSL. Consequently, the k_z axis forms a nodal line, no matter the dispersion along k_x, k_y directions is linear or not. This situation does not occur in the type-IV magnetic space groups, but indeed occurs in type-III magnetic space groups.

Since $[\boldsymbol{b}_z]$ carries the identity Rep of H, and the product Rep $M(H)\otimes M^*(H)$ must contain the identity Rep, thus the dispersion of the degenerate energy curve at the HSP along the nodal line direction contains linear term.

Case II: the little cogroup $G_0(\boldsymbol{k})$ of a HSP contains $C_{nv}\times Z_2^{\tilde{T}}$ as a real subgroup, namely, $H\supset C_{nv}$. As clarified, the HSL along the k_z direction crossing this HSP has the little cogroup $C_{nv}\times Z_2^{\tilde{T}}$. If this HSL forms a nodal line, it should satisfy one of the following two conditions.

(1) $[\boldsymbol{b}_z]$ carries a nontrivial 1-dimensional Rep of H, and the product Rep $M(H)\otimes M^*(H)$ does not contain the Rep carried by $[\boldsymbol{b}_z]$. In this case, the CG coefficient coupling to the identity Rep forms an identity matrix $\Gamma = I$, therefore, the possible perturbation along k_z direction is $k_z^2 I$, which does not lift the 4-fold degeneracy. In other words, the dispersion of the energy curve at the HSP along the nodal line direction is quadratic.

(2) the vector Rep of H is irreducible, and $M(H)\otimes M^*(H)$ does not contain the vector Rep carried by $[\boldsymbol{b}_x, \boldsymbol{b}_y, \boldsymbol{b}_z]$. In this

case, the HSLs along k_x, k_y, k_z directions are all nodal lines, and the dispersions of the energy curve at the HSP along the nodal lines are quadratic.

Another possibility is that $[\boldsymbol{b}_z]$ carries the identity Rep of H [and hence of $G_0(\boldsymbol{k})$]. In this case, k_z cannot lift the degeneracy of the HSP, hence the HSL has the same degeneracy as the HSP and forms a nodal line. The product Rep $M(H) \otimes M^*(H)$ always contains the Rep carried by $[\boldsymbol{b}_z]$ (i.e., the identity Rep), thus the dispersion of the degenerate energy curve at the HSP along the nodal line direction is linear. However, the only point group H satisfying above requirements is C_{nv}, which goes back to the Case-I.

In Table I, we provide all the directions of nodal lines crossing the HSPs of the BZ.

IV. INSTRUCTION TO THE TABLES

The central results of the present work are listed in Table I.

The first column shows the number of magnetic space groups and the second column lists the HSPs and the corresponding little cogroups $[G_0(\boldsymbol{k})]$ as well as the dimensions (dim) of the IPReps for fermionic particles at the given HSPs. If dim $= n$ with $n = 4$ or 8, then it means that all the IPReps are of n dimensional. For the cases with "dim $= m|n$" (m, n are two integers with $m \leqslant n$), m stands for the lowest dimension of the IPReps of the same class and n is the dimension of the present IPRep. Take the Shubinikov space group 221.97 IV as an example. The $G_0(\boldsymbol{k})$ at R point is $O_h \times Z_2^T$, the projective Rep of class $(-1, +1, -1, +1, +1)$ has one 8-dim irreducible Rep and two inequivalent 4-dim irreducible Reps (see Table VI). For "dim $= 4|8$", the first number 4 stands for the lowest dimension of the IPReps of $O_h \times Z_2^T$ and the second number 8 is the dimension of the IPRep discussed at present (we are discussing the dispersion and nodal line the 8-dim IPRep may lead to). Similarly, "dim $= 4|4_{1,2}$" shows that we are discussing the dispersion and nodal line the two inequivalent 4-dim IPReps may lead to.

The third column shows the values of the gauge invariants that label the second group cohomology classification of the projective Reps.

In the fourth column of Table I, we list the lowest order dispersions, which are polynomials of $\delta\boldsymbol{k}$.

Different dispersion terms of $\delta\boldsymbol{k}$ belong to different irreducible linear Reps of $G_0(\boldsymbol{k})$. When one irreducible linear Rep of $G_0(\boldsymbol{k})$ corresponds to linear dispersion term of $\delta\boldsymbol{k}$, if it is 3-dimensional, we denote it as $[k_x, k_y, k_z]$; if it is 2-dimensional in (k_x, k_y) plane, we denote it as $[k_x, k_y]$; if it is 1-dimensional only in the direction of k_z, we denote it as k_z. Here, k_x, k_y, k_z are bases of irreducible linear Rep of $G_0(\boldsymbol{k})$. When the irreducible linear Rep of $G_0(\boldsymbol{k})$ corresponds to quadratic or cubic dispersion term of $\delta\boldsymbol{k}$, the bases of irreducible linear Rep can be k_xk_y, k_xk_z, k_yk_z, $k_xk_yk_z$, $[k_zk_x, k_zk_y]$, $[k_xk_y, k_xk_z, k_yk_z]$, $\cdots$. The bracketed terms correspond to bases of 2-dim or 3-dim irreducible linear Rep of $G_0(\boldsymbol{k})$.

The last column provides the possible nodal-line directions crossing the given HSP. It should be noticed that if the little cogroup belongs to one of the groups $D_{3h} \times Z_2^{\tilde{T}}$, $D_6 \times Z_2^{\tilde{T}}$, $D_{6h} \times Z_2^T$, $O_h \times Z_2^T$, then there are two or three inequivalent IPReps for the given class, the information of these inequivalent IPReps is listed separately. Our results only depend on the symmetry group and are not sensitive to the details of the material.

For most of the HSPs and HSLs listed in Table I, the IPReps are of 4-dimensional (dim $= 4$). We enumerate the exceptions as follows. For the group $G_0(\boldsymbol{k}) = O_h \times Z_2^T$, some classes contain both 4-dimensional (dim $= 4|4$) and 8-dimensional (dim $= 4|8$) IPReps in certain classes. If the 8-dimensional IPRep has different dispersions with the 4-dimensional IPRep, then the dispersion of the former is given in a different row. Especially, for the group $G_0(\boldsymbol{k}) = D_{4h} \times Z_2^T$, several classes only contain 8-dimensional IPReps (dim $= 8$). When the lowest dimension of the IPReps is 4, the dispersions of the corresponding HSP are completely determined by the terms listed in Table I and must have a nodal structure. For example, for the group 11.57 IV, the HSPs C and E both have dim $= 4$, and the dispersions are linear along k_x, k_y, k_z directions, so the energy dispersions at C and E must be of Dirac-cone type, no matter the energy is close to the fermi level or not.

At some HSPs, the lowest dimension of the IPReps is 2 but the same class contains 4-dimensional (dim $= 2|4$) or 6-dimensional (dim $= 2|6$) IPReps. For $G_0(\boldsymbol{k}) = T \times Z_2^{\tilde{T}}$, $T_d \times Z_2^{\tilde{T}}$, $T_h \times Z_2^T$ with dim $= 2|6$, the dispersion terms describe bands, which carry the 6-dimensional IPReps. For other cases with dim $= 2|4$, the dispersion terms describe the bands, which carry the 4-dimensional IPReps. Different from the case with lowest dimension dim $= 4$, the nodal structures are not guaranteed if dim $= 2|4$ or dim $= 2|6$, and the results are dependent on the details of the materials.

The information of the intermediate steps in obtaining Table I is provided in Tables II–VI.

Table III shows all inequivalent IPReps and their corresponding invariants (label of classification) for antiunitary groups (with specific factor systems) that appeared in our discussion. The set of invariants marked by $(*)$ belongs to the same class of $\omega_2^{(\frac{1}{2})}(g_1, g_2)$, which is the factor system of the double valued Rep [up to a gauge transformation (3)]. In other words, a Rep with mark $(*)$ can be mapped to a double valued Rep under a gauge transformation followed by a unitary transformation. Since isomorphic groups have the same (projective) Reps, we consider isomorphic groups as the same abstract group when listing their IPReps in Table III.

Here we clarify the notations that have been used. C_{2m}, $C_{4m}^{\pm}$ with $m = x, y, z$ label the 2-fold or 4-fold axis along $\hat{x}, \hat{y}, \hat{z}$ respectively; $C_{3j}^{\pm}$ with $j = 1, 2, 3, 4$ label four different 3-fold axes along $\hat{x}+\hat{y}+\hat{z}$, $\hat{x}+\hat{y}-\hat{z}$, $-\hat{x}+\hat{y}+\hat{z}$, $\hat{x}-\hat{y}+\hat{z}$, respectively; C_2 labels 2-fold axis along $\hat{z}$, C_{2i}' with $i = 1, 2, 3$ label three different 2-fold axes $\hat{x}$, $\hat{x}-\sqrt{3}\hat{y}$, $\hat{x}+\sqrt{3}\hat{y}$, respectively, C_{2i}'' with $i = 1, 2, 3$ label three different 2-fold axes $\hat{y}$, $\sqrt{3}\hat{x}+\hat{y}$, $\sqrt{3}\hat{x}-\hat{y}$, respectively; C_{2p} with $p = a, b, c, d, e, f$ label six different 2-fold axes along $\hat{x}+\hat{y}$, $\hat{x}-\hat{y}$, $\hat{x}+\hat{z}$, $\hat{y}+\hat{z}$, $\hat{x}-\hat{z}$, $\hat{y}-\hat{z}$, respectively. These notations can be found in Fig 1.1, Fig 1.2, and Fig 1.3 of Ref. [43]. Furthermore, $\mathcal{I}$ stands for spacial inversion, $\mathcal{M}$ denotes planar mirror reflection. Some combined operations containing the spacial inversion $\mathcal{I}$ are replaced by brief notations: $\mathcal{I}T = \tilde{T}$, $\mathcal{I}C_2 = \mathcal{M}_h$, $\mathcal{I}C_{2m} = \mathcal{M}_m$, $\mathcal{I}C_{2i}' = \mathcal{M}_{di}$,

$\mathcal{I}C''_{2i} = \mathcal{M}_{vi}, \mathcal{I}C_{2p} = \mathcal{M}_{dp}, \mathcal{I}C_3^{\pm} = S_6^{\mp}, \mathcal{I}C_{4m}^{\pm} = S_{4m}^{\mp}, \mathcal{I}C_6^{\pm} = S_3^{\mp}, \mathcal{I}C_{3j}^{\pm} = S_{6j}^{\mp}$.

All of the abstract groups under our consideration have the structure $G = H \times Z_2^{\mathbb{T}}$ where H is a finite unitary group and $Z_2^{\mathbb{T}} = \{E, \mathbb{T}\}$ with $\mathbb{T}$ an abstract antiunitary group satisfying $\mathbb{T}^2 = E$. When mapped to the little cogroups $G_0(\boldsymbol{k})$, H corresponds to a point group, and $\mathbb{T}$ can be interpreted as $\tilde{T}$ owing to (9). However, in Tables I and III, we identify $\mathbb{T}$ as T if $T \in G_0(\boldsymbol{k})$ (in this case $G_0(\boldsymbol{k})$ is the little cogroup of type IV magnetic space groups and $\{T|\boldsymbol{\tau}_0\}$ with $\boldsymbol{\tau}_0 \neq 0$ is symmetry operation) and identify $\mathbb{T}$ as $\tilde{T}$ if $T \notin G_0(\boldsymbol{k})$. The correspondence between abstract groups and concrete magnetic point groups are listed in Table II, where we also provide the physical meaning of the generators and the gauge invariants, which label the classification of the IPReps.

The IPReps of some big groups are listed in separate tables, namely, the group $O(T_d) \times Z_2^{\tilde{T}}$ is listed in Table IV, the group $T_h \times Z_2^T$ is listed in Table V, and the group $O_h \times Z_2^T$ is listed in Table VI. Because $\mathcal{H}^2(D_{2h} \times Z_2^T, U(1)) = \mathcal{H}^2(D_{4h} \times Z_2^T, U(1)) = \mathcal{H}^2(D_{6h} \times Z_2^T, U(1)) = \mathbb{Z}_2^7$, there are 128 different classes of projective Reps for each of the above groups. We do not list the matrix forms of irreducible Reps for every class.

V. POTENTIAL MATERIALS

Our symmetry rules are helpful to search for candidate magnetic materials, which support Dirac-cone or nodal-line band structures. The results are consistent with the band structures for itinerant electrons obtained from first principle calculations of a number of magnetic materials [39].

For instance, the uranium intermetallic compounds U_2Pd_2In[49] has the 127.394 magnetic space group symmetry. A transition metal element Pd and a magnetic atom U are contained. The little cogroup $G_0(\boldsymbol{k})$ of the M point and the A point is $D_{2d}^2 \times Z_2^{\tilde{T}}$, which has a 4-dim IPRep and supports linear dispersions in the (k_x, k_y) plane. On the HSL V(MA) (along k_z direction), the little cogroup is $C_{2v}^3 \times Z_2^{\tilde{T}}$ whose IPRep is 4-dimensional. Therefore, U_2Pd_2In is a magnetic nodal-line semimetal. Similar candidate nodal line materials also include $CeCo_2P_2$(126.386) [50], UP_2(130.432) [51], NdZn(222.103) [52].

We list several candidate materials hosting nodal-point structures. The rare earth compound YFe_4Ge_2 [53] has magnetic atom Fe, whose magnetic space group symmetry is 58.399. The little cogroup $G_0(\boldsymbol{k})$ of the Z point and the S point is $D_2^1 \times Z_2^{\tilde{T}}$ whose IPRep is 4-dimensional. The dispersions along k_x, k_y, k_z directions are all linear. So YFe_4Ge_2 hosts Dirac-cone structure at the vicinity of Z and S points. The rare earth compound $LuFe_4Ge_2$ [54] has the same magnetic group symmetry as YFe_4Ge_2, hence it is also a magnetic nodal-point semimetal. Similarly, the cubic crystal compounds NpTe, NpSe, and NpS [55] have the magnetic group symmetry 228.139 and support nodal-point semimetal at X point.

VI. CONCLUSION AND DISCUSSION

In conclusion, we study the spectrum degeneracy and the dispersion around the degenerate nodal points/lines in the BZ for itinerant electrons in magnetic materials preserving type-III or type-IV Shubnikov magnetic space group symmetries. In our discussion the degeneracies are resulting from high-dimensional IPReps of the little cogroups. We provide the criteria for judging Dirac cones, nodal lines and other type dispersions around the high-degeneracy points.

For all of the type-III and type-IV Shubnikov magnetic space groups, which contain $\{\tilde{T}|\tau_{\tilde{T}}\}$ as a group element (namely, $\tilde{T} = \mathcal{I}T$ belongs to the little cogroup of the HSPs), we list the complete information of the HSPs and dispersion information. Our paper provides guidelines for experimental realization of topological semimetals in magnetic materials.

It should be mentioned that, although our symmetry analysis predicts the existence of degeneracies at the HSPs/HSLs and the corresponding dispersions, we cannot guarantee that these nodal points/lines appear precisely at (or close) to the fermion energy. The positions of the nodal points/lines depend on the detailed chemical components of the materials.

Despite the IPReps protection, nodal points (such as the Dirac cones) can also appear at some point in certain HSLs where two bands carrying inequivalent IPReps cross each other [13]. Furthermore, degenerate nodal points/lines may also exist in magnetic materials whose magnetic little cogroup does not contain $\tilde{T}$ as an element (in this case the double degeneracy in the whole BZ is not protected). Finally, our method can also be applied to analyze the band structure of bosonic quasiparticles (such as the magnons) or fractional excitations (such as anyons in topologically ordered phases).

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APPENDIX A: PROJECTIVE REPS OF ANTIUNITARY GROUPS

Projective Reps and the factor systems. As discussed in the main text, the little cogroups have the structure $G = H \times Z_2^{\mathbb{T}}$ with $Z_2^{\mathbb{T}} = \{E, \mathbb{T}\}$, $\mathbb{T}^2 = E$, where the physical meaning of $\mathbb{T}$ will be specified later. Supposing g is a group element of G, then it is represented by $M(g)$ if g is a unitary element and represented by $M(g)K$ if g is antiunitary, where K is the complex-conjugate operator satisfying $KU = U^*K$ with U an arbitrary matrix and U^* its complex conjugation.

The multiplication of (projective) Reps of g_1, g_2 depends on if they are unitary or antiunitary. If we define $s(g)$

$$s(g) = \begin{cases} 1, & \text{if } g \text{ is unitary}, \\ -1, & \text{if } g \text{ is antiunitary}, \end{cases}$$

and the corresponding operator $K_{s(g)}$

$$K_{s(g)} = \begin{cases} I, & \text{if} s(g) = 1, \\ K, & \text{if} s(g) = -1, \end{cases}$$

then we have the multiplication rule of a projective Rep,

$$M(g_1)K_{s(g_1)}M(g_2)K_{s(g_2)} = M(g_1g_2)e^{i\theta_2(g_1,g_2)}K_{s(g_1g_2)},$$

where the $U(1)$ phase factor $\omega_2(g_1, g_2) \equiv e^{i\theta_2(g_1,g_2)}$ is a function of two group variables and is called the *factor system*. If $\omega_2(g_1, g_2) = 1$ for any $g_1, g_2 \in G$, then above projective Rep becomes a linear Rep.

Substituting above results into the associativity relation of the sequence of operations $g_1 \times g_2 \times g_3$, we can obtain

$$\begin{aligned} &M(g_1)K_{s(g_1)}M(g_2)K_{s(g_2)}M(g_3)K_{s(g_3)} \\ &= M(g_1g_2g_3)\omega_2(g_1, g_2)\omega_2(g_1g_2, g_3)K_{s(g_1g_2g_3)} \\ &= M(g_1g_2g_3)\omega_2(g_1, g_2g_3)\omega_2^{s(g_1)}(g_2, g_3)K_{s(g_1g_2g_3)}, \end{aligned}$$

namely,

$$\omega_2(g_1, g_2)\omega_2(g_1g_2, g_3) = \omega_2^{s(g_1)}(g_2, g_3)\omega_2(g_1, g_2g_3). \quad \text{(A1)}$$

Equation (A1) is the general relation that the factor systems of any finite group (no matter unitary or antiunitary) should satisfy. If we introduce a gauge transformation $M'(g)K_{s(g)} = M(g)\Omega_1(g)K_{s(g)}$, where the phase factor $\Omega_1(g) = e^{i\theta_1(g)}$ depends on a single group variable, then the factor system changes into

$$\omega_2'(g_1, g_2) = \omega_2(g_1, g_2)\Omega_2(g_1, g_2), \quad \text{(A2)}$$

with

$$\Omega_2(g_1, g_2) = \frac{\Omega_1(g_1)\Omega_1^{s(g_1)}(g_2)}{\Omega_1(g_1g_2)}. \quad \text{(A3)}$$

The equivalent relations (A2) and (A3) define the equivalent classes of the solutions of (A1). The number of equivalent classes for a finite group is usually finite.

The 2-cocycles and the 2nd group cohomology. The factor systems (A1) of projective Reps of group G are also called cocycles. The equivalent classes of the cocycles form a group, i.e., the group-cohomology group. The group cohomology [56] {Kernel d/Image d} is defined by the coboundary operator d

$$\begin{aligned} &(d\omega_n)(g_1, \ldots, g_{n+1}) \\ &= [g_1 \cdot \omega_n(g_2, \ldots, g_{n+1})]\omega_n^{(-1)^{n+1}}(g_1, \ldots, g_n) \\ &\quad \times \prod_{i=1}^{n} \omega_n^{(-1)^i}(g_1, \ldots, g_{i-1}, g_ig_{i+1}, g_{i+2}, \ldots, g_{n+1}). \quad \text{(A4)} \end{aligned}$$

where $g_1, ..., g_{n+1} \in G$ and the variables $\omega_n(g_1, \ldots, g_n)$ take value in an Abelian coefficient group $\mathcal{A}$ [usually $\mathcal{A}$ is a subgroup of $U(1)$, in the present work $\mathcal{A} = U(1)$]. The set of variables $\omega_n(g_1, \ldots, g_n)$ is called a n cochain. For antiunitary groups the module $g\cdot$ is defined by

$$g \cdot \omega_n(g_1, \ldots, g_n) = \omega_n^{s(g)}(g_1, \ldots, g_n).$$

With this notation, Eq. (A1) can be rewritten as

$$(d\omega_2)(g_1, g_2, g_3) = 1,$$

the solutions of above equations are called 2-cocycles with $U(1)$-coefficient. Similarly, Eq. (A3) can be rewritten as

$$\Omega_2(g_1, g_2) = (d\Omega_1)(g_1, g_2),$$

where $\Omega_1(g_1), \Omega_1(g_2) \in U(1)$ and $\Omega_2(g_1, g_2)$ are called 2-coboundaries. Two 2-cocycles $\omega_2'(g_1, g_2)$ and $\omega_2(g_1, g_2)$ are equivalent if they differ by a 2-coboundary, see Eq. (A2). The equivalent classes of the 2-cocycles $\omega_2(g_1, g_2)$ form the second group cohomology $\mathcal{H}^2(G, U(1))$.

Writing $\omega_2(g_1, g_2) = e^{i\theta_2(g_1,g_2)}$, where $\theta_2(g_1, g_2) \in [0, 2\pi)$, then the cocycle equations $(d\omega_2)(g_1, g_2, g_3) = 1$ can be written in terms of linear equations,

$$\begin{aligned} &s(g_1)\theta_2(g_2, g_3) - \theta_2(g_1g_2, g_3) + \theta_2(g_1, g_2g_3) \\ &\quad -\theta_2(g_1, g_2) = 0. \quad \text{(A5)} \end{aligned}$$

Similarly, if we write $\Omega_1(g_1) = e^{i\theta_1(g_1)}$ and $\Omega_2(g_1, g_2) = e^{i\Theta_2(g_1,g_2)}$, then the 2-coboundary (A3) can be written as

$$\Theta_2(g_1, g_2) = s(g_1)\theta_1(g_2) - \theta_1(g_1g_2) + \theta_1(g_1). \quad \text{(A6)}$$

The equal sign in (A5) and (A6) means equal mod 2π. From these linear equations, we can obtain the solution space of the cocycle equations, as well as the classes that the solutions belong to. The set of classes forms a finite Abelian group, which labels the classification of the projective Reps.

Invariants of projective Reps. The second group-cohomology group is generated by a certain number of *invariants*. The invariants are, by definition, invariant under the gauge transformation (A2) and (A3). They are formed by independent functions of the cocycles $\omega_2(g_1, g_2)$. For instance, for the unitary group $D_2 = Z_2 \times Z_2 = \{E, P\} \times \{E, Q\}$ with $P^2 = E, Q^2 = E$, the classification of 2-cocycles is

$$\mathcal{H}^2(D_2, U(1)) = \mathbb{Z}_2,$$

there is only one independent invariant, which is given by $\chi = \frac{\omega_2(P,Q)}{\omega_2(Q,P)}$. Another example is the simplest antiunitary group $Z_2^{\mathbb{T}} = \{E, \mathbb{T}\}$, which has

$$\mathcal{H}^2(Z_2^{\mathbb{T}}, U(1)) = \mathbb{Z}_2,$$

with the invariant $\chi_{\mathbb{T}} = \omega_2(\mathbb{T}, \mathbb{T})$.

Generally, for any group G, if $\mathcal{H}^2(G, U(1)) = \mathbb{Z}_2^n$, then the 2-cocycles of G have n invariants, each taking value $+1$ or -1. The invariants of several antiunitary groups are given in Table II.

Regular projective Reps and irreducible projective Reps. For a given factor system, we can easily construct the corresponding regular projective Rep (the regular Rep twisted by the 2-cocycles) using the group space as the Rep space. The group element g is not only an operator $\hat{g}$, but also a basis $|g\rangle$. The operator $\hat{g}_1$ acts on the basis $|g_2\rangle$ as the following,

$$\hat{g}_1|g_2\rangle = e^{i\theta_2(g_1,g_2)}K_{s(g_1)}|g_1g_2\rangle, \quad \text{(A7)}$$

or in matrix form

$$\hat{g}_1 = M(g_1)K_{s(g_1)}, \quad \text{(A8)}$$

with matrix element

$$M(g_1)_{g,g_2} = \langle g|\hat{g}_1|g_2\rangle = e^{i\theta_2(g_1,g_2)}\delta_{g,g_1g_2}. \quad \text{(A9)}$$

TABLE II. Correspondence between some abstract groups $H \times Z_2^{\mathbb{T}}$ and concrete groups, where $\mathbb{T}$ is an abstract antiunitary operation with $\mathbb{T}^2 = E$, $\mathcal{I}$ = space inversion, T = time reversal, $\mathcal{M}$ = mirror reflection plane, $Z_2^{\mathbb{T}} = \{E, \mathbb{T}\}$, $Z_2^T = \{E, T\}$, $Z_2^{\tilde{T}} = \{E, \tilde{T}\}$ with $\tilde{T} = \mathcal{I}T$. In the fourth column, we list all the classification labels of projective Rep. The invariants are interpreted as the following: $\chi_T \equiv \omega_2(T, T)$, $\chi_{\tilde{T}} \equiv \omega_2(\tilde{T}, \tilde{T})$, $\chi_{TC_2} \equiv \omega_2(TC_2, TC_2)$, $\chi_{T\mathcal{M}} \equiv \omega_2(T\mathcal{M}, T\mathcal{M})$.

Abstract group	Concrete group	Generators	Classification labels
$(Z_2 \times Z_2) \times Z_2^{\mathbb{T}}$	$C_{2v}^1 \times Z_2^{\tilde{T}}$	$P = C_{2x}, Q = \mathcal{M}_y, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_y,C_{2x})}{\omega_2(C_{2x},\mathcal{M}_y)}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_x}, \chi_{TC_{2y}})$
	$C_{2v}^2 \times Z_2^{\tilde{T}}$	$P = \mathcal{M}_x, Q = C_{2y}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_x,C_{2y})}{\omega_2(C_{2y},\mathcal{M}_x)}, \chi_{\tilde{T}}, \chi_{TC_{2x}}, \chi_{T\mathcal{M}_y})$
	$C_{2v}^3 \times Z_2^{\tilde{T}}$	$P = \mathcal{M}_x, Q = \mathcal{M}_y, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_x,\mathcal{M}_y)}{\omega_2(\mathcal{M}_y,\mathcal{M}_x)}, \chi_{\tilde{T}}, \chi_{TC_{2x}}, \chi_{TC_{2y}})$
	$C_{2v}^4 \times Z_2^{\tilde{T}}$	$P = C'_{21}, Q = \mathcal{M}_{v1}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_{v1},C'_{21})}{\omega_2(C'_{21},\mathcal{M}_{v1})}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_{d1}}, \chi_{TC''_{21}})$
	$C_{2v}^5 \times Z_2^{\tilde{T}}$	$P = \mathcal{M}_{d1}, Q = C''_{21}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_{d1},C''_{21})}{\omega_2(C''_{21},\mathcal{M}_{d1})}, \chi_{\tilde{T}}, \chi_{TC'_{21}}, \chi_{T\mathcal{M}_{v1}})$
	$D_2^1 \times Z_2^{\tilde{T}}$	$P = C_{2x}, Q = C_{2y}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C_{2y},C_{2x})}{\omega_2(C_{2x},C_{2y})}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_x}, \chi_{T\mathcal{M}_y})$
	$D_2^2 \times Z_2^{\tilde{T}}$	$P = C_{2b}, Q = C_{2a}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C_{2b},C_{2a})}{\omega_2(C_{2a},C_{2b})}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_{db}}, \chi_{T\mathcal{M}_{da}})$
	$D_2^3 \times Z_2^{\tilde{T}}$	$P = C'_{21}, Q = C''_{21}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C'_{21},C''_{21})}{\omega_2(C''_{21},C'_{21})}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_{d1}}, \chi_{T\mathcal{M}_{v1}})$
	$D_2^4 \times Z_2^{\tilde{T}}$	$P = C_{2f}, Q = C_{2d}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C_{2f},C_{2d})}{\omega_2(C_{2d},C_{2f})}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_{df}}, \chi_{T\mathcal{M}_{dd}})$
	$C_{2h}^1 \times Z_2^T$	$P = C_{2z}, Q = \mathcal{I}, \mathbb{T} = T$	$(\frac{\omega_2(\mathcal{I},C_{2z})}{\omega_2(C_{2z},\mathcal{I})}, \chi_T, \chi_{TC_{2z}}, \chi_{\tilde{T}})$
	$C_{2h}^2 \times Z_2^T$	$P = C_{2x}, Q = \mathcal{I}, \mathbb{T} = T$	$(\frac{\omega_2(\mathcal{I},C_{2x})}{\omega_2(C_{2x},\mathcal{I})}, \chi_T, \chi_{TC_{2x}}, \chi_{\tilde{T}})$
$(Z_2 \times Z_2 \times Z_2) \times Z_2^{\mathbb{T}}$	$D_{2h}^1 \times Z_2^T$	$C_{2x}, C_{2y}, \mathcal{I}, T$	$(\frac{\omega_2(C_{2x},C_{2y})}{\omega_2(C_{2y},C_{2x})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC_{2x}}, \chi_{TC_{2y}}, \frac{\omega_2(C_{2x},\mathcal{I})}{\omega_2(\mathcal{I},C_{2x})}, \frac{\omega_2(C_{2y},\mathcal{I})}{\omega_2(\mathcal{I},C_{2y})})$
	$D_{2h}^2 \times Z_2^T$	$C_{2b}, C_{2a}, \mathcal{I}, T$	$(\frac{\omega_2(C_{2b},C_{2a})}{\omega_2(C_{2a},C_{2b})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC_{2b}}, \chi_{TC_{2a}}, \frac{\omega_2(C_{2b},\mathcal{I})}{\omega_2(\mathcal{I},C_{2b})}, \frac{\omega_2(C_{2a},\mathcal{I})}{\omega_2(\mathcal{I},C_{2a})})$
	$D_{2h}^3 \times Z_2^T$	$C'_{21}, C''_{21}, \mathcal{I}, T$	$(\frac{\omega_2(C'_{21},C''_{21})}{\omega_2(C''_{21},C'_{21})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC'_{21}}, \chi_{TC''_{21}}, \frac{\omega_2(C'_{21},\mathcal{I})}{\omega_2(\mathcal{I},C'_{21})}, \frac{\omega_2(C''_{21},\mathcal{I})}{\omega_2(\mathcal{I},C''_{21})})$
$(Z_4 \rtimes Z_2) \times Z_2^{\mathbb{T}}$	$C_{4v} \times Z_2^{\tilde{T}}$	$P = C_{4z}^+, Q = \mathcal{M}_x, \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_x,\mathcal{M}_y)}{\omega_2(\mathcal{M}_y,\mathcal{M}_x)}, \chi_{\tilde{T}}, \chi_{TC_{2x}}, \chi_{TC_{2a}})$
	$D_{2d}^1 \times Z_2^{\tilde{T}}$	$P = S_{4z}^-, Q = C_{2x}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C_{2y},C_{2x})}{\omega_2(C_{2x},C_{2y})}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_x}, \chi_{TC_{2a}})$
	$D_{2d}^2 \times Z_2^{\tilde{T}}$	$P = S_{4z}^-, Q = \mathcal{M}_x, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_y,\mathcal{M}_x)}{\omega_2(\mathcal{M}_x,\mathcal{M}_y)}, \chi_{\tilde{T}}, \chi_{TC_{2x}}, \chi_{T\mathcal{M}_{da}})$
	$D_{2d}^3 \times Z_2^{\tilde{T}}$	$P = S_{4y}^-, Q = C_{2z}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C_{2z},C_{2x})}{\omega_2(C_{2x},C_{2z})}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_z}, \chi_{TC_{2c}})$
	$D_{2d}^4 \times Z_2^{\tilde{T}}$	$P = S_{4x}^+, Q = \mathcal{M}_y, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_y,\mathcal{M}_z)}{\omega_2(\mathcal{M}_z,\mathcal{M}_y)}, \chi_{\tilde{T}}, \chi_{TC_{2y}}, \chi_{T\mathcal{M}_{df}})$
	$D_4^1 \times Z_2^{\tilde{T}}$	$P = C_{4z}^+, Q = C_{2x}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C_{2y},C_{2x})}{\omega_2(C_{2x},C_{2y})}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_x}, \chi_{T\mathcal{M}_{da}})$
	$D_4^2 \times Z_2^{\tilde{T}}$	$P = C_{4y}^+, Q = C_{2z}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C_{2z},C_{2x})}{\omega_2(C_{2x},C_{2z})}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_z}, \chi_{T\mathcal{M}_{dc}})$
$(Z_4 \times Z_2) \times Z_2^{\mathbb{T}}$	$C_{4h} \times Z_2^T$	$P = C_{4z}^+, Q = \mathcal{I}, \mathbb{T} = T$	$(\frac{\omega_2(C_{4z}^+,\mathcal{I})}{\omega_2(\mathcal{I},C_{4z}^+)}, \chi_T, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_z})$
$[(Z_4 \rtimes Z_2) \times Z_2] \times Z_2^{\mathbb{T}}$	$D_{4h}^1 \times Z_2^T$	$C_{4z}^+, C_{2x}, \mathcal{I}, T$	$(\frac{\omega_2(C_{2x},C_{2y})}{\omega_2(C_{2y},C_{2x})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC_{2x}}, \chi_{TC_{2a}}, \frac{\omega_2(C_{2x},\mathcal{I})}{\omega_2(\mathcal{I},C_{2x})}, \frac{\omega_2(C_{2a},\mathcal{I})}{\omega_2(\mathcal{I},C_{2a})})$
	$D_{4h}^2 \times Z_2^T$	$C_{4y}^+, C_{2z}, \mathcal{I}, T$	$(\frac{\omega_2(C_{2x},C_{2z})}{\omega_2(C_{2z},C_{2x})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC_{2z}}, \chi_{TC_{2c}}, \frac{\omega_2(C_{2z},\mathcal{I})}{\omega_2(\mathcal{I},C_{2z})}, \frac{\omega_2(C_{2c},\mathcal{I})}{\omega_2(\mathcal{I},C_{2c})})$
$(Z_6 \rtimes Z_2) \times Z_2^{\mathbb{T}}$	$C_{6v} \times Z_2^{\tilde{T}}$	$P = C_6^+, Q = \mathcal{M}_{d1}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C_2,\mathcal{M}_{d1})}{\omega_2(\mathcal{M}_{d1},C_2)}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_h}, \chi_{TC'_{21}})$
	$D_{3h}^1 \times Z_2^{\tilde{T}}$	$P = S_3^-, Q = C'_{21}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_h,C'_{21})}{\omega_2(C'_{21},\mathcal{M}_h)}, \chi_{\tilde{T}}, \chi_{TC_2}, \chi_{T\mathcal{M}_{d1}})$
	$D_{3h}^2 \times Z_2^{\tilde{T}}$	$P = S_3^-, Q = \mathcal{M}_{d1}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(\mathcal{M}_h,\mathcal{M}_{d1})}{\omega_2(\mathcal{M}_{d1},\mathcal{M}_h)}, \chi_{\tilde{T}}, \chi_{TC_2}, \chi_{TC'_{21}})$
	$D_6 \times Z_2^{\tilde{T}}$	$P = C_6^+, Q = C'_{21}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\frac{\omega_2(C_2,C'_{21})}{\omega_2(C'_{21},C_2)}, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_h}, \chi_{T\mathcal{M}_{d1}})$
	$D_{3d}^1 \times Z_2^T$	$P = S_6^+, Q = C'_{21}, \mathbb{T} = T$	$(\frac{\omega_2(\mathcal{I},C'_{21})}{\omega_2(C'_{21},\mathcal{I})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC'_{21}})$
	$D_{3d}^2 \times Z_2^T$	$P = S_6^+, Q = C''_{21}, \mathbb{T} = T$	$(\frac{\omega_2(\mathcal{I},C''_{21})}{\omega_2(C''_{21},\mathcal{I})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC''_{21}})$
	$D_{3d}^3 \times Z_2^T$	$P = S_{61}^+, Q = C_{2b}, \mathbb{T} = T$	$(\frac{\omega_2(\mathcal{I},C_{2b})}{\omega_2(C_{2b},\mathcal{I})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC_{2b}})$
$(Z_6 \times Z_2) \times Z_2^{\mathbb{T}}$	$C_{6h} \times Z_2^T$	$P = C_6^+, Q = \mathcal{I}, \mathbb{T} = T$	$(\frac{\omega_2(C_6^+,\mathcal{I})}{\omega_2(\mathcal{I},C_6^+)}, \chi_T, \chi_{\tilde{T}}, \chi_{T\mathcal{M}_h})$
$(Z_3 \rtimes Z_2) \times Z_2^{\mathbb{T}}$	$C_{3v}^1 \times Z_2^{\tilde{T}}$	$P = C_3^+, Q = \mathcal{M}_{d1}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\chi_{\tilde{T}}, \chi_{TC'_{21}})$
	$C_{3v}^2 \times Z_2^{\tilde{T}}$	$P = C_{31}^+, Q = \mathcal{M}_{db}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\chi_{\tilde{T}}, \chi_{TC_{2b}})$
	$D_3^1 \times Z_2^{\tilde{T}}$	$P = C_3^+, Q = C'_{21}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\chi_{\tilde{T}}, \chi_{T\mathcal{M}_{d1}})$
	$D_3^2 \times Z_2^{\tilde{T}}$	$P = C_3^+, Q = C''_{21}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\chi_{\tilde{T}}, \chi_{T\mathcal{M}_{v1}})$
	$D_3^3 \times Z_2^{\tilde{T}}$	$P = C_{31}^+, Q = C_{2b}, \mathbb{T} = \tilde{T} = \mathcal{I}T$	$(\chi_{\tilde{T}}, \chi_{T\mathcal{M}_{db}})$

TABLE II. (*Continued.*)

Abstract group	Concrete group	Generators	Classification labels
$[(Z_6 \rtimes Z_2)\times Z_2]\times Z_2^{\mathbb{T}}$	$D_{6h}\times Z_2^T$	$C_6^+, C'_{21}, \mathcal{I}, T$	$(\frac{\omega_2(C'_{21},C''_{21})}{\omega_2(C''_{21},C'_{21})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC'_{21}}, \chi_{TC''_{21}}, \frac{\omega_2(C'_{21},\mathcal{I})}{\omega_2(\mathcal{I},C'_{21})}, \frac{\omega_2(C''_{21},\mathcal{I})}{\omega_2(\mathcal{I},C''_{21})})$
$A_4\times Z_2^{\mathbb{T}}$	$T\times Z_2^{\tilde{T}}$	$P=C_{31}^-, Q=C_{33}^+, \mathbb{T}=\tilde{T}=\mathcal{I}T$	$(\chi_{\tilde{T}}, \chi_{T\mathcal{M}_z})$
$(A_4\rtimes Z_2)\times Z_2^{\mathbb{T}}$	$O\times Z_2^{\tilde{T}}$	$C_{31}^-, C_{33}^+, C_{2f}, \tilde{T}$	$(\chi_{\tilde{T}}, \chi_{T\mathcal{M}_z}, \chi_{T\mathcal{M}_{df}})$
	$T_d\times Z_2^{\tilde{T}}$	$C_{31}^-, C_{33}^+, \mathcal{M}_{df}, \tilde{T}$	$(\chi_{\tilde{T}}, \chi_{T\mathcal{M}_z}, \chi_{TC_{2f}})$
$(A_4\times Z_2)\times Z_2^{\mathbb{T}}$	$T_h\times Z_2^T$	$C_{31}^-, C_{33}^+, \mathcal{I}, T$	$(\frac{\omega_2(C_{2x},C_{2y})}{\omega_2(C_{2y},C_{2x})}, \chi_T, \chi_{\tilde{T}})$
$[(A_4\rtimes Z_2)\times Z_2]\times Z_2^{\mathbb{T}}$	$O_h\times Z_2^T$	$C_{31}^-, C_{33}^+, C_{2f}, \mathcal{I}, T$	$(\frac{\omega_2(C_{2x},C_{2y})}{\omega_2(C_{2y},C_{2x})}, \chi_T, \chi_{\tilde{T}}, \chi_{TC_{2a}}, \frac{\omega_2(C_{2a},\mathcal{I})}{\omega_2(\mathcal{I},C_{2a})})$

For any group element g_3, we have

$$\begin{aligned}\hat{g}_1\hat{g}_2|g_3\rangle &= \hat{g}_1[e^{i\theta_2(g_2,g_3)}K_{s(g_2)}|g_2g_3\rangle]\\ &= e^{i\theta_2(g_1,g_2g_3)}K_{s(g_1)}[e^{i\theta_2(g_2,g_3)}K_{s(g_2)}|g_1g_2g_3\rangle]\\ &= e^{i\theta_2(g_1,g_2g_3)}e^{is(g_1)\theta_2(g_2,g_3)}K_{s(g_1g_2)}|g_1g_2g_3\rangle,\end{aligned}$$

and

$$\widehat{g_1g_2}|g_3\rangle = e^{i\theta_2(g_1g_2,g_3)}K_{s(g_1g_2)}|g_1g_2g_3\rangle.$$

Comparing with the 2-cocycle equation (A5), it is easily obtained that $\hat{g}_1\hat{g}_2 = e^{i\theta_2(g_1,g_2)}\widehat{g_1g_2}$. In matrix form, this relation reads

$$M(g_1)K_{s(g_1)}M(g_2)K_{s(g_2)} = e^{i\theta_2(g_1,g_2)}M(g_1g_2)K_{s(g_1g_2)}. \quad \text{(A10)}$$

Eq. (A10) indicates that $M(g)K_{s(g)}$ is indeed a projective Rep of the group G. For the trivial 2-cocycle where $e^{i\theta_2(g_1,g_2)}=1$ for all $g_1, g_2\in G$, $M(g)K_{s(g)}$ reduces to the regular linear Rep of G.

For a given group G and factor system $\omega_2(g_1,g_2)$, all of the inequivalent irreducible projective Reps can be obtained by reducing the regular projective Rep using the eigenfunction method. The details of the method is provided in Ref. [47] and they will not be repeated here. The complete results of IPReps of relevant antiunitary groups for given factor systems are provided in Tables III–VI.

APPENDIX B: VERIFICATION OF COCYCLE EQ. (5) FOR THE FACTOR SYSTEM

For the phase factor

$$\omega_2(g_1,g_2) = e^{-i\boldsymbol{K}_1\cdot\boldsymbol{\tau}_2}, \quad \text{(B1)}$$

where reciprocal lattice vector $\boldsymbol{K}_1 = s(g_1)(g_1^{-1}\boldsymbol{k}-\boldsymbol{k})$, τ_2 is fractional translation associated with $g_2\in G_0(\boldsymbol{k})$.

For any $g_1, g_2, g_3\in G_0(\boldsymbol{k})$,

$$\begin{aligned}&\omega_2(g_1,g_2g_3)\omega_2^{s(g_1)}(g_2,g_3)\\ &= e^{-i\boldsymbol{K}_1\cdot\boldsymbol{\tau}_{23}}e^{-is(g_1)\boldsymbol{K}_2\cdot\boldsymbol{\tau}_3}\\ &= e^{-i\boldsymbol{K}_1\cdot\boldsymbol{\tau}_2}e^{-i\boldsymbol{K}_1\cdot g_2\boldsymbol{\tau}_3}e^{-is(g_1)\boldsymbol{K}_2\cdot\boldsymbol{\tau}_3}\\ &= e^{-i\boldsymbol{K}_1\cdot\boldsymbol{\tau}_2}e^{-is(g_2)g_2^{-1}\boldsymbol{K}_1\cdot\boldsymbol{\tau}_3}e^{-is(g_1)\boldsymbol{K}_2\cdot\boldsymbol{\tau}_3}\\ &= e^{-i\boldsymbol{K}_1\cdot\boldsymbol{\tau}_2}e^{-is(g_2)s(g_1)[(g_1g_2)^{-1}\boldsymbol{k}-g_2^{-1}\boldsymbol{k}]\cdot\boldsymbol{\tau}_3}\\ &\quad\cdot e^{-is(g_1)s(g_2)(g_2^{-1}\boldsymbol{k}-\boldsymbol{k})\cdot\boldsymbol{\tau}_3}\\ &= e^{-iK_1\cdot\tau_2}e^{-is(g_1g_2)[(g_1g_2)^{-1}k-k]\cdot\tau_3}\\ &= e^{-i\boldsymbol{K}_1\cdot\boldsymbol{\tau}_2}e^{-i\boldsymbol{K}_{12}\cdot\boldsymbol{\tau}_3}\\ &= \omega_2(g_1,g_2)\omega_2(g_1g_2,g_3),\end{aligned} \quad \text{(B2)}$$

where we use $\boldsymbol{\tau}_{23} = \boldsymbol{\tau}_2 + g_2\boldsymbol{\tau}_3 + \boldsymbol{R}_{23}$ with the lattice vector $\boldsymbol{R}_{23}$, $\boldsymbol{K}_{12} = s(g_1g_2)[(g_1g_2)^{-1}\boldsymbol{k}-\boldsymbol{k}]$, and $\boldsymbol{K}_1\cdot g_2\boldsymbol{\tau}_3 = s(g_2)g_2^{-1}K_1\cdot\tau_3$. It is obvious that the cocycle equation (A1) is satisfied and the phase factor (B1) is factor system of projective Rep of $G_0(\boldsymbol{k})$ at HSPs of BZ.

APPENDIX C: SPECIAL GROUPS IN TABLE I

For $G_0(\boldsymbol{k}) = C_{2h}^1\times Z_2^T$, the class $(-1,-1,-1,-1)$ and the class $(-1,+1,-1,-1)$ each has a 4-dim IPRep. For the class $(-1,+1,-1,-1)$, the perturbations that lift the degeneracy belong to A_u(1-fold), B_u(1-fold) or B_g(3-fold) Reps, while for the class $(-1,-1,-1,-1)$ the perturbations belong to A_u(3-fold), B_u(1-fold) or B_g(1-fold) Reps. Since k_z belongs to the Rep A_u, the dispersion along k_z direction is linear. The B_g Reps includes the quadratic terms k_xk_z, k_yk_z and higher-order terms. The B_u Rep includes $k_x, k_y, k_x^3, k_y^3, k_x^2k_y, k_xk_y^2$. From equation (23), B_u occurs only once in both of the classes $(-1,-1,-1,-1)$ and $(-1,+1,-1,-1)$. So we need to consider a combination of all of the possible terms, namely,

$$H_{B_u} = (ak_x + bk_y + ck_x^3 + dk_y^3 + ek_x^2k_y + fk_xk_y^2 + \dots)\Gamma^{(B_u)}, \quad \text{(C1)}$$

where $a\sim f$ are nonuniversal constants. Apart from one special direction of the (k_x,k_y) plane, H_{B_u} has only linear dispersion terms ak_x+bk_y. But in the special direction, the cubic dispersion can appear. In the direction perpendicular to the special direction, the dispersion is linear, so

$$H_{B_u} = (a'k_m + b'k_n^3)\Gamma^{(B_u)}, \quad \text{(C2)}$$

where a', b' are nonuniversal constants, and $\boldsymbol{m}\parallel(a,b,0)^T$, $\boldsymbol{n}\parallel(b,-a,0)^T$ with $\boldsymbol{n}\perp\boldsymbol{m}$. Therefore, the leading dispersion terms includes k_m, k_n^3, k_z in orthonormal bases $[\boldsymbol{b}_m, \boldsymbol{b}_n, \boldsymbol{b}_z]$. The special direction depends on the detail of material.

For $G_0(\boldsymbol{k}) = D_6\times Z_2^{\tilde{T}}$, class $(-1,-1,+1,-1)$ has three inequivalent 4-dim IPReps, one has linear dispersion k_z and cubic dispersions $k_x^3-3k_xk_y^2$, $k_y^3-3k_yk_x^2$, the other two have linear dispersions $[k_x,k_y]$ and k_z. All the three 4-dim Reps have no nodal lines.

For $G_0(\boldsymbol{k}) = D_{3h}^2\times Z_2^{\tilde{T}}$, class $(-1,-1,-1,+1)$ has two inequivalent 4-dim IPReps, one has linear dispersion k_z,

TABLE III. IPReps of abstract antiunitary groups that appeared in the main text. We only list the Rep matrices of the generators. The symbols $\sigma_{x,y,z}$ are the three Pauli matrices, I is the 2×2 identity matrix, $\omega = e^{i\frac{2\pi}{3}}$, $\omega^{\frac{1}{2}} = e^{i\frac{\pi}{3}}$, l.c. denotes "label of classification", K means the complex conjugate operator, $(*)$ labels the double valued Rep.

Group		Rep of generators		l.c.
$(Z_2\times Z_2)\times Z_2^{\mathbb{T}}$	$\mathbb{T}$	P	Q	
	K	1	1	$(+1,+1,+1,+1)$
	K	1	-1	
	K	-1	1	
	K	-1	-1	
	$\sigma_x K$	$-I$	$i\sigma_z$	$(+1,+1,+1,-1)$
	$\sigma_x K$	I	$i\sigma_z$	
	$\sigma_x K$	$i\sigma_z$	$-I$	$(+1,+1,-1,+1)$
	$\sigma_x K$	$i\sigma_z$	I	
	$\sigma_x K$	$i\sigma_z$	$i\sigma_z$	$(+1,+1,-1,-1)$
	$\sigma_x K$	$i\sigma_z$	$-i\sigma_z$	
	$\sigma_y K$	$i\sigma_z$	$-i\sigma_z$	$(+1,-1,+1,+1)$
	$\sigma_y K$	$i\sigma_z$	$i\sigma_z$	
	$\sigma_y K$	$i\sigma_z$	$-I$	$(+1,-1,+1,-1)$
	$\sigma_y K$	$i\sigma_z$	I	$C_{2h}\times Z_2^T$ $(*)$
	$\sigma_y K$	$-I$	$i\sigma_z$	$(+1,-1,-1,+1)$
	$\sigma_y K$	I	$i\sigma_z$	
	$\sigma_y K$	I	I	$(+1,-1,-1,-1)$
	$\sigma_y K$	I	$-I$	
	$\sigma_y K$	$-I$	I	
	$\sigma_y K$	$-I$	$-I$	
	IK	$i\sigma_z$	$i\sigma_x$	$(-1,+1,+1,+1)$
	IK	$i\sigma_z$	σ_y	$(-1,+1,+1,-1)$
	IK	σ_y	$i\sigma_z$	$(-1,+1,-1,+1)$
	$\sigma_x\otimes\sigma_x K$	$I\otimes\sigma_z$	$\sigma_z\otimes\sigma_y$	$(-1,+1,-1,-1)$
	$\sigma_y K$	σ_z	σ_x	$(-1,-1,+1,+1)$
				$D_2(C_{2v})\times Z_2^{\tilde{T}}$ $(*)$
	$\sigma_y\otimes\sigma_x K$	$I\otimes\sigma_z$	$iI\otimes\sigma_x$	$(-1,-1,+1,-1)$
	$\sigma_y\otimes\sigma_x K$	$i\sigma_z\otimes\sigma_z$	$\sigma_z\otimes\sigma_x$	$(-1,-1,-1,+1)$
	$\sigma_y\otimes\sigma_x K$	$i\sigma_z\otimes\sigma_z$	$iI\otimes\sigma_y$	$(-1,-1,-1,-1)$
$(Z_4\times Z_2)\times Z_2^{\mathbb{T}}$	$\mathbb{T}$	P	Q	
	K	1	1	$(+1,+1,+1,+1)$
	K	1	-1	
	K	-1	1	
	K	-1	-1	
	$\sigma_x K$	$i\sigma_z$	$-I$	
	$\sigma_x K$	$i\sigma_z$	I	
	$\sigma_x K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-I$	$(+1,+1,+1,-1)$
	$\sigma_x K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	I	
	$\sigma_x K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	I	
	$\sigma_x K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-I$	
	$\sigma_x K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_z$	$(+1,+1,-1,+1)$
	$\sigma_x K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_x K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_x K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_z$	
	$\sigma_x K$	I	$-i\sigma_z$	$(+1,+1,-1,-1)$
	$\sigma_x K$	$i\sigma_z$	$i\sigma_z$	
	$\sigma_x K$	$-I$	$-i\sigma_z$	
	$\sigma_x K$	$-i\sigma_z$	$i\sigma_z$	

TABLE III. (*Continued*.)

Group	Rep of generators			l.c.
	$\sigma_y K$	$-I$	$-i\sigma_z$	$(+1, -1, +1, +1)$
	$\sigma_y K$	$i\sigma_z$	$-i\sigma_z$	
	$\sigma_y K$	I	$i\sigma_z$	
	$\sigma_y K$	$i\sigma_z$	$i\sigma_z$	
	$\sigma_y K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_z$	$(+1, -1, +1, -1)$
	$\sigma_y K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_y K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_y K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_z$	
	$\sigma_y K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-I$	$(+1, -1, -1, +1)$
	$\sigma_y K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	I	$(*)$
	$\sigma_y K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	I	
	$\sigma_y K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-I$	
	$\sigma_y K$	I	I	$(+1, -1, -1, -1)$
	$\sigma_y K$	I	$-I$	
	$\sigma_y K$	$-I$	I	
	$\sigma_y K$	$-I$	$-I$	
	$\sigma_y K$	$i\sigma_z$	I	
	$\sigma_y K$	$i\sigma_z$	$-I$	
	IK	$i\sigma_z$	$i\sigma_x$	$(-1, +1, +1, +1)$
	$\sigma_x K$	σ_z	$i\sigma_x$	
	$\sigma_x \otimes \sigma_x K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_y \otimes I$	$(-1, +1, +1, -1)$
	$\sigma_x \otimes \sigma_x K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$\sigma_x \otimes \sigma_z$	$(-1, +1, -1, +1)$
	IK	$i\sigma_z$	σ_y	$(-1, +1, -1, -1)$
	$\sigma_x \otimes \sigma_x K$	$I \otimes \sigma_z$	$\sigma_z \otimes \sigma_y$	
	$\sigma_y K$	σ_z	σ_x	$(-1, -1, +1, +1)$
	$\sigma_y \otimes IK$	$I \otimes i\sigma_z$	$I \otimes \sigma_y$	
	$\sigma_x \otimes \sigma_y K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$\sigma_x \otimes \sigma_z$	$(-1, -1, +1, -1)$
	$\sigma_x \otimes \sigma_y K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_y \otimes I$	$(-1, -1, -1, +1)$
	$\sigma_x \otimes \sigma_y K$	$I \otimes \sigma_z$	$\sigma_z \otimes i\sigma_y$	$(-1, -1, -1, -1)$
	$\sigma_x \otimes \sigma_y K$	$i\sigma_z \otimes \sigma_z$	$\sigma_z \otimes i\sigma_y$	
$(Z_4 \rtimes Z_2) \times Z_2^{\mathbb{T}}$	$\mathbb{T}$	P	Q	
	K	1	1	$(+1, +1, +1, +1)$
	K	1	-1	
	K	-1	1	
	K	-1	-1	
	$\sigma_x K$	$i\sigma_z$	σ_x	
	$\sigma_x K$	$i\sigma_z$	iI	$(+1, +1, +1, -1)$
	$\sigma_x K$	$i\sigma_z$	$-iI$	
	IK	σ_z	$i\sigma_x$	
	$\sigma_x K$	$-i\sigma_z$	σ_z	$(+1, +1, -1, +1)$
	$\sigma_x K$	$i\sigma_z$	σ_z	
	IK	σ_z	σ_y	

TABLE III. (*Continued.*)

Group	Rep of generators			l.c.
	$\sigma_x K$	$-I$	$i\sigma_z$	$(+1, +1, -1, -1)$
	$\sigma_x K$	I	$i\sigma_z$	
	$\sigma_x \otimes \sigma_z K$	$i\sigma_z \otimes \sigma_z$	$iI \otimes \sigma_x$	
	$\sigma_y K$	$-I$	$i\sigma_z$	$(+1, -1, +1, +1)$
	$\sigma_y K$	I	$i\sigma_z$	
	$\sigma_y K$	$i\sigma_y$	$i\sigma_z$	
	$\sigma_y K$	$-i\sigma_z$	σ_z	$(+1, -1, +1, -1)$
	$\sigma_y K$	$i\sigma_z$	σ_z	
	$\sigma_y \otimes \sigma_x K$	$\sigma_z \otimes \sigma_z$	$-\sigma_z \otimes \sigma_y$	
	$\sigma_y K$	$i\sigma_z$	iI	$(+1, -1, -1, +1)$
	$\sigma_y K$	$i\sigma_z$	$-iI$	
	$\sigma_y \otimes \sigma_x K$	$\sigma_z \otimes \sigma_z$	$iI \otimes \sigma_y$	
$(Z_4 \rtimes Z_2) \times Z_2^{\mathbb{T}}$	$\mathbb{T}$	P	Q	
	$\sigma_y K$	I	I	$(+1, -1, -1, -1)$
	$\sigma_y K$	I	$-I$	
	$\sigma_y K$	$-I$	I	
	$\sigma_y K$	$-I$	$-I$	
	$\sigma_x \otimes \sigma_y K$	$iI \otimes \sigma_z$	$\sigma_z \otimes \sigma_x$	
	$\sigma_x K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_x$	$(-1, +1, +1, +1)$
	$\sigma_x K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_x$	
	$I \otimes \sigma_x K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$\sigma_x \otimes \sigma_y$	$(-1, +1, +1, -1)$
	$\sigma_z \otimes \sigma_x K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_x \otimes \sigma_y$	$(-1, +1, -1, +1)$
	$\sigma_x \otimes \sigma_x K$	$I \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$\sigma_z \otimes \sigma_y$	$(-1, +1, -1, -1)$
	$\sigma_x \otimes \sigma_x K$	$-I \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-\sigma_z \otimes \sigma_y$	
	$\sigma_y K$	$\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-\sigma_x$	$(-1, -1, +1, +1)$
	$\sigma_y K$	$-\begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	σ_x	$(*)$
	$I \otimes \sigma_y K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_x \otimes \sigma_x$	$(-1, -1, +1, -1)$
	$I \otimes \sigma_y K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-\sigma_y \otimes \sigma_y$	$(-1, -1, -1, +1)$
	$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$iI \otimes \sigma_y$	$(-1, -1, -1, -1)$
	$\sigma_y \otimes \sigma_x K$	$-I \otimes \begin{pmatrix} e^{i\frac{\pi}{4}} & 0 \\ 0 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-iI \otimes \sigma_y$	
$(Z_3 \rtimes Z_2) \times Z_2^{\mathbb{T}}$	$P\mathbb{T}$	Q		
	K	1		$(+1, +1)$
	K	-1		
	$\begin{pmatrix} 0 & \omega \\ \omega^2 & 0 \end{pmatrix} K$	σ_x		
	$\sigma_x K$	σ_z		$(+1, -1)$
	$\sigma_y \otimes \begin{pmatrix} 0 & e^{i\frac{\pi}{6}} \\ e^{-i\frac{\pi}{6}} & 0 \end{pmatrix} K$	$I \otimes \sigma_x$		
	$\sigma_y K$	σ_z		$(-1, +1)$
	$\begin{pmatrix} 0 & e^{i\frac{\pi}{6}} \\ e^{-i\frac{\pi}{6}} & 0 \end{pmatrix} K$	$i\sigma_y$		$(*)$

TABLE III. (*Continued.*)

Group	Rep of generators			l.c.
	$\sigma_y K$	I		$(-1, -1)$
	$\sigma_y K$	$-I$		
	$\sigma_x \otimes \begin{pmatrix} 0 & e^{i\frac{\pi}{6}} \\ e^{-i\frac{\pi}{6}} & 0 \end{pmatrix} K$	$\sigma_z \otimes \sigma_x$		
$(Z_6 \times Z_2) \times Z_2^{\mathbb{T}}$	$\mathbb{T}$	P	Q	
	K	1	1	$(+1, +1, +1, +1)$
	K	1	-1	
	K	-1	1	
	K	-1	-1	
	$\sigma_x K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	I	
	$\sigma_x K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$-I$	
	$\sigma_x K$	$-\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$-I$	
	$\sigma_x K$	$-\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	I	
	$\sigma_x K$	$\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$-I$	$(+1, +1, +1, -1)$
	$\sigma_x K$	$i\sigma_z$	$-I$	
	$\sigma_x K$	$\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	I	
	$\sigma_x K$	$i\sigma_z$	I	
	$\sigma_x K$	$-\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	I	
	$\sigma_x K$	$-\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$-I$	
	$\sigma_x K$	$-\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$i\sigma_z$	$(+1, +1, -1, +1)$
	$\sigma_x K$	$\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_x K$	$-\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_x K$	$\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$i\sigma_z$	
	$\sigma_x K$	$i\sigma_z$	$i\sigma_z$	
	$\sigma_x K$	$i\sigma_z$	$-i\sigma_z$	
	$\sigma_x K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$-i\sigma_z$	$(+1, +1, -1, -1)$
	$\sigma_x K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$i\sigma_z$	
	$\sigma_x K$	$-I$	$-i\sigma_z$	
	$\sigma_x K$	I	$-i\sigma_z$	
	$\sigma_x K$	$-\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$i\sigma_z$	
	$\sigma_x K$	$-\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_y K$	$-I$	$-i\sigma_z$	$(+1, -1, +1, +1)$
	$\sigma_y K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_y K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$i\sigma_z$	
	$\sigma_y K$	I	$-i\sigma_z$	
	$\sigma_y K$	$-\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$i\sigma_z$	
	$\sigma_y K$	$-\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_y K$	$i\sigma_z$	$i\sigma_z$	$(+1, -1, +1, -1)$
	$\sigma_y K$	$\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$-i\sigma_z$	
	$\sigma_y K$	$\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$i\sigma_z$	
	$\sigma_y K$	$i\sigma_z$	$-i\sigma_z$	
	$\sigma_y K$	$-\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$-i\sigma_z$	

TABLE III. (*Continued.*)

Group	Rep of generators			l.c.
	$\sigma_y K$	$-\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$i\sigma_z$	
	$\sigma_y K$	$\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$-I$	$(+1,-1,-1,+1)$
	$\sigma_y K$	$-\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$-I$	$(*)$
	$\sigma_y K$	$\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	I	
	$\sigma_y K$	$i\sigma_z$	$-I$	
	$\sigma_y K$	$-\begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	I	
	$\sigma_y K$	$i\sigma_z$	I	
$(Z_6 \times Z_2) \times Z_2^{\mathbb{T}}$	$\mathbb{T}$	P	Q	
	$\sigma_y K$	$-I$	$-I$	$(+1,-1,-1,-1)$
	$\sigma_y K$	$-\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	I	
	$\sigma_y K$	$-I$	I	
	$\sigma_y K$	$-\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$-I$	
	$\sigma_y K$	I	$-I$	
	$\sigma_y K$	I	I	
	$\sigma_y K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	I	
	$\sigma_y K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$-I$	
	$\sigma_x K$	σ_z	$i\sigma_y$	$(-1,+1,+1,+1)$
	$\sigma_x \otimes \sigma_x K$	$\sigma_z \otimes \begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$i\sigma_y \otimes I$	
	IK	$i\sigma_z$	$i\sigma_x$	$(-1,+1,+1,-1)$
	$\sigma_x \otimes \sigma_x K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$i\sigma_x \otimes I$	
	IK	$i\sigma_z$	σ_y	$(-1,+1,-1,+1)$
	$\sigma_y \otimes \sigma_y K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$\sigma_y \otimes I$	
	$\sigma_x \otimes \sigma_x K$	$\sigma_z \otimes \begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$\sigma_x \otimes \sigma_z$	$(-1,+1,-1,-1)$
	$\sigma_x \otimes \sigma_x K$	$\sigma_z \otimes I$	$\sigma_x \otimes \sigma_z$	
	$\sigma_y K$	σ_z	σ_x	$(-1,-1,+1,+1)$
	$\sigma_y \otimes \sigma_x K$	$\sigma_z \otimes \begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$\sigma_x \otimes I$	
	$\sigma_x \otimes \sigma_y K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$\sigma_x \otimes \sigma_z$	$(-1,-1,+1,-1)$
	$\sigma_x \otimes \sigma_y K$	$\sigma_z \otimes i\sigma_z$	$\sigma_x \otimes \sigma_z$	
	$\sigma_x \otimes \sigma_y K$	$\sigma_z \otimes \begin{pmatrix} e^{i\frac{\pi}{6}} & 0 \\ 0 & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$i\sigma_y \otimes I$	$(-1,-1,-1,+1)$
	$\sigma_x \otimes \sigma_y K$	$\sigma_z \otimes i\sigma_z$	$i\sigma_y \otimes I$	
	$\sigma_x \otimes \sigma_y K$	$\sigma_z \otimes \begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	$i\sigma_y \otimes I$	$(-1,-1,-1,-1)$
	$\sigma_x \otimes \sigma_y K$	$\sigma_z \otimes I$	$i\sigma_y \otimes I$	
$(Z_6 \rtimes Z_2) \times Z_2^{\mathbb{T}}$	$\mathbb{T}$	P	Q	
	K	1	1	$(+1,+1,+1,+1)$
	K	1	-1	
	K	-1	1	
	K	-1	-1	
	$\sigma_x K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	σ_x	
	$\sigma_x K$	$-\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	σ_x	
	$\sigma_x K$	I	$i\sigma_z$	$(+1,+1,+1,-1)$
	$\sigma_x K$	$-I$	$i\sigma_z$	

TABLE III. (*Continued.*)

Group	Rep of generators			l.c.
	$\sigma_y\otimes\sigma_yK$	$I\otimes\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$iI\otimes\sigma_y$	
	$\sigma_y\otimes\sigma_yK$	$-I\otimes\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$iI\otimes\sigma_y$	
	σ_xK	$i\sigma_z$	I	$(+1,+1,-1,+1)$
	σ_xK	$i\sigma_z$	$-I$	
	$\sigma_z\otimes\sigma_xK$	$\sigma_z\otimes\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$\sigma_y\otimes\sigma_y$	
	σ_xK	$i\sigma_z$	$i\sigma_z$	$(+1,+1,-1,-1)$
	σ_xK	$i\sigma_z$	$-i\sigma_z$	
	$\sigma_z\otimes\sigma_xK$	$\sigma_z\otimes\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$i\sigma_x\otimes\sigma_y$	
	σ_yK	$i\sigma_z$	$i\sigma_z$	$(+1,-1,+1,+1)$
	σ_yK	$i\sigma_z$	$-i\sigma_z$	
	$I\otimes\sigma_yK$	$\sigma_z\otimes\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$i\sigma_x\otimes\sigma_x$	
	σ_yK	$i\sigma_z$	I	$(+1,-1,+1,-1)$
	σ_yK	$i\sigma_z$	$-I$	
	$I\otimes\sigma_yK$	$\sigma_z\otimes\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$\sigma_y\otimes\sigma_x$	
	σ_yK	I	$i\sigma_z$	$(+1,-1,-1,+1)$
	σ_yK	$-I$	$i\sigma_z$	$D_{3d}\times Z_2^T$ $(*)$
	σ_yK	$\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$i\sigma_y$	
	σ_yK	$-\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$i\sigma_y$	
	σ_yK	I	I	$(+1,-1,-1,-1)$
	σ_yK	I	$-I$	
	σ_yK	$-I$	I	
	σ_yK	$-I$	$-I$	
	$\sigma_x\otimes\sigma_yK$	$I\otimes\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$\sigma_z\otimes\sigma_x$	
	$\sigma_x\otimes\sigma_yK$	$-I\otimes\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$\sigma_z\otimes\sigma_x$	
	IK	σ_z	$i\sigma_x$	$(-1,+1,+1,+1)$
	$\sigma_z\otimes\sigma_xK$	$\sigma_z\otimes\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$i\sigma_y\otimes\sigma_x$	
	IK	σ_z	σ_y	$(-1,+1,+1,-1)$
	$I\otimes\sigma_xK$	$\sigma_z\otimes\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$\sigma_y\otimes\sigma_y$	
	σ_xK	$\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$i\sigma_y$	$(-1,+1,-1,+1)$
	σ_xK	$-\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$i\sigma_y$	
	σ_xK	$i\sigma_z$	$i\sigma_y$	
	$\sigma_x\otimes\sigma_xK$	$I\otimes\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$\sigma_z\otimes\sigma_x$	$(-1,+1,-1,-1)$
	$\sigma_x\otimes\sigma_xK$	$-I\otimes\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$\sigma_z\otimes\sigma_x$	
	$\sigma_x\otimes\sigma_xK$	$I\otimes i\sigma_z$	$\sigma_z\otimes\sigma_x$	
	σ_yK	$\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	σ_x	$(-1,-1,+1,+1)$
	σ_yK	$-\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	σ_x	$D_6(C_{6v},D_{3h})\times Z_2^{\tilde{T}}$ $(*)$
	σ_yK	$i\sigma_z$	σ_x	
	$\sigma_y\otimes\sigma_xK$	$I\otimes\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$iI\otimes\sigma_y$	$(-1,-1,+1,-1)$
	$\sigma_y\otimes\sigma_xK$	$-I\otimes\begin{pmatrix}e^{i\frac{\pi}{6}}&0\\0&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$iI\otimes\sigma_y$	
	$\sigma_y\otimes\sigma_xK$	$I\otimes i\sigma_z$	$iI\otimes\sigma_y$	

TABLE III. (*Continued.*)

Group	Rep of generators			l.c.
	$I\otimes\sigma_y K$	$\sigma_z\otimes\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$\sigma_x\otimes\sigma_x$	$(-1,-1,-1,+1)$
	$I\otimes\sigma_y K$	$\sigma_z\otimes I$	$\sigma_x\otimes\sigma_x$	
	$\sigma_z\otimes\sigma_y K$	$\sigma_z\otimes I$	$i\sigma_x\otimes\sigma_x$	$(-1,-1,-1,-1)$
	$\sigma_z\otimes\sigma_y K$	$\sigma_z\otimes\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$i\sigma_x\otimes\sigma_x$	
$A_4\times Z_2^{\mathbb{T}}$	$\mathbb{T}$	P	Q	
	K	1	1	$(+1,+1)$
	$\sigma_x K$	$\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$\begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	
	$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$\begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	$\frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	
	$\sigma_y\otimes\sigma_y K$	$I\otimes\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$-I\otimes\frac{\sqrt{3}}{3}\begin{pmatrix}e^{-i\frac{\pi}{6}}&\sqrt{2}i\\\sqrt{2}i&e^{i\frac{\pi}{6}}\end{pmatrix}$	$(+1,-1)$
	$\sigma_x\otimes IK$	$\begin{pmatrix}1&0&0&0\\0&\omega^2&0&0\\0&0&1&0\\0&0&0&\omega\end{pmatrix}$	$\frac{\sqrt{3}}{3}\begin{pmatrix}i&\sqrt{2}e^{-i\frac{\pi}{6}}&0&0\\\sqrt{2}e^{-i\frac{\pi}{6}}&e^{i\frac{\pi}{6}}&0&0\\0&0&-i&\sqrt{2}e^{i\frac{\pi}{6}}\\0&0&\sqrt{2}e^{i\frac{\pi}{6}}&e^{-i\frac{\pi}{6}}\end{pmatrix}$	
	$\sigma_y K$	$-\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$\frac{\sqrt{3}}{3}\begin{pmatrix}e^{-i\frac{\pi}{6}}&\sqrt{2}i\\\sqrt{2}i&e^{i\frac{\pi}{6}}\end{pmatrix}$	$(-1,+1)$
	$\sigma_y\otimes IK$	$-\begin{pmatrix}1&0&0&0\\0&\omega^2&0&0\\0&0&1&0\\0&0&0&\omega\end{pmatrix}$	$-\frac{\sqrt{3}}{3}\begin{pmatrix}i&\sqrt{2}e^{-i\frac{\pi}{6}}&0&0\\\sqrt{2}e^{-i\frac{\pi}{6}}&e^{i\frac{\pi}{6}}&0&0\\0&0&-i&\sqrt{2}e^{i\frac{\pi}{6}}\\0&0&\sqrt{2}e^{i\frac{\pi}{6}}&e^{-i\frac{\pi}{6}}\end{pmatrix}$	$(*)$
	$\sigma_y K$	$-I$	$-I$	$(-1,-1)$
	$\sigma_y K$	$-\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$-\begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	
	$\sigma_y\otimes\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$-I\otimes\begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	$-I\otimes\frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	

TABLE IV. The Reps of $O(T_d)\times Z_2^{\tilde{T}}\simeq(A_4\rtimes Z_2)\times Z_2^{\mathbb{T}}$. The symbols $\sigma_{x,y,z}$ are the three Pauli matrices, I is the 2×2 identity matrix, $\omega=e^{i\frac{2\pi}{3}}$, $\omega^{\frac{1}{2}}=e^{i\frac{\pi}{3}}$, l.c. denotes "label of classification", K stands for complex conjugation, $(*)$ labels the double valued Rep.

$O(T_d)\times Z_2^{\tilde{T}}$	$\tilde{T}$	C_{31}^-	l.c.
	C_{33}^+	$C_{2f}(\mathcal{M}_{df})$	
	K	1	$(+1,+1,+1)$
	1	1;	
	K	1	
	1	-1;	
	$\sigma_x K$	$\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	
	$\begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	σ_y;	
	$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$\begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
	$\frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$;	
	$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$\begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
	$\frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$-\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	

TABLE IV. (*Continued.*)

$O(T_d)\times Z_2^{\tilde{T}}$	$\tilde{T}$ / C_{33}^{+}	C_{31}^{-} / $C_{2f}(\mathcal{M}_{df})$	l.c.
	$\sigma_x K$	I	$(+1,+1,-1)$
	$-I$	$i\sigma_z$;	
	$\sigma_x\otimes\sigma_x K$	$I\otimes\begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	
	$-I\otimes\begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$i\sigma_z\otimes\sigma_y$;	
	$\sigma_x\otimes\begin{pmatrix}1 & 0 & 0\\ 0 & 0 & 1\\ 0 & 1 & 0\end{pmatrix}K$	$I\otimes\begin{pmatrix}1 & 0 & 0\\ 0 & \omega^2 & 0\\ 0 & 0 & \omega\end{pmatrix}$	
	$-I\otimes\frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}}\\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2\\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}}\end{pmatrix}$	$i\sigma_z\otimes\begin{pmatrix}1 & 0 & 0\\ 0 & 0 & 1\\ 0 & 1 & 0\end{pmatrix}$	
	$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix}e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	$(+1,-1,+1)$
	$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix}e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$-\sigma_z\otimes\sigma_y$;	
	$\sigma_x\otimes IK$	$-\frac{\sqrt{2}}{4}\begin{pmatrix}e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}}\\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3}\\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1\\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}}\end{pmatrix}$	
	$\frac{\sqrt{2}}{4}\begin{pmatrix}e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}}\\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3}\\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1\\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}}\end{pmatrix}$	$I\otimes\sigma_x$	
$O(T_d)$ $\times Z_2^{\tilde{T}}$	$\tilde{T}$ / C_{33}^{+}	C_{31}^{-} / $C_{2f}(\mathcal{M}_{df})$	l.c.
	$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix}e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	$(+1,-1,-1)$
	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix}e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$iI\otimes\sigma_y$;	
	$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix}e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	
	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix}e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$-iI\otimes\sigma_y$;	
	$(\sigma_y\otimes I)\otimes\sigma_y K$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix}e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}}\\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3}\\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1\\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}}\end{pmatrix}$	
	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix}e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}}\\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3}\\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1\\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}}\end{pmatrix}$	$i(I\otimes I)\otimes\sigma_x$	
	$\sigma_y K$	$\frac{\sqrt{2}}{2}\begin{pmatrix}e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	$(-1,+1,+1)$
	$\frac{\sqrt{2}}{2}\begin{pmatrix}e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$i\sigma_y$;	$(*)$
	$\sigma_y K$	$\frac{\sqrt{2}}{2}\begin{pmatrix}e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	
	$\frac{\sqrt{2}}{2}\begin{pmatrix}e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$-i\sigma_y$;	
	$I\otimes\sigma_y K$	$-\frac{\sqrt{2}}{4}\begin{pmatrix}e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}}\\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3}\\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1\\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}}\end{pmatrix}$	
	$-\frac{\sqrt{2}}{4}\begin{pmatrix}e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}}\\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3}\\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1\\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}}\end{pmatrix}$	$iI\otimes\sigma_x$	

TABLE IV. (*Continued.*)

$O(T_d) \times Z_2^{\tilde{T}}$	$\tilde{T}$	C_{31}^-	l.c.
	C_{33}^+	$C_{2f}(\mathcal{M}_{df})$	
	$\sigma_x \otimes \sigma_y K$	$I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1, +1, -1)$
	$-I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-\sigma_z \otimes \sigma_y$;	
	$(\sigma_y \otimes \sigma_x) \otimes IK$	$-I \otimes \frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
	$I \otimes \frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-(I \otimes I) \otimes \sigma_x$	
	$\sigma_y K$	I	$(-1, -1, +1)$
	$-I$	$i\sigma_z$;	
	$\sigma_y K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	
	$-\begin{pmatrix} \omega^2 & 0 \\ 0 & \omega \end{pmatrix}$	$i\sigma_y$;	
	$\sigma_y \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} K$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & \omega^2 & 0 \\ 0 & 0 & \omega \end{pmatrix}$	
	$-I \otimes \frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}} \\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2 \\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$	
	$\sigma_y K$	I	$(-1, -1, -1)$
	I	I;	
	$\sigma_y K$	I	
	I	$-I$;	
	$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	
	$I \otimes \begin{pmatrix} \omega^2 & 0 \\ 0 & \omega \end{pmatrix}$	$I \otimes \sigma_y$;	
	$\sigma_y \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} K$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & \omega^2 & 0 \\ 0 & 0 & \omega \end{pmatrix}$	
	$I \otimes \frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}} \\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2 \\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$;	
	$\sigma_y \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} K$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & \omega^2 & 0 \\ 0 & 0 & \omega \end{pmatrix}$	
	$I \otimes \frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}} \\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2 \\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$-I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$	

TABLE V. The Reps of $T_h \times Z_2^T \simeq (A_4 \times Z_2) \times Z_2^{\mathbb{T}}$. The symbols $\sigma_{x,y,z}$ are the three Pauli matrices, I is the 2×2 identity matrix, $\omega = e^{i\frac{2\pi}{3}}$, $\omega^{\frac{1}{2}} = e^{i\frac{\pi}{3}}$, l.c. denotes "label of classification", K stands for complex conjugation, $(*)$ labels the double valued Rep.

$T_h \times Z_2^T$	T	C_{31}^-	l.c.
	C_{33}^+	$\mathcal{I}$	
	K	1	$(+1, +1, +1)$
	1	1;	
	K	1	
	1	-1;	
	$\sigma_x K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	
	$\begin{pmatrix} \omega^2 & 0 \\ 0 & \omega \end{pmatrix}$	I;	

TABLE V. (*Continued.*)

$T_h \times Z_2^T$	T	C_{31}^-	l.c.
	C_{33}^+	$\mathcal{I}$	
	$\sigma_x K$	$\begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	
	$\begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$-I$;	
	$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$\begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
	$\frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$;	
	$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$\begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
	$\frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$-\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$	
	$\sigma_x K$	$\begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	$(+1, +1, -1)$
	$\begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$i\sigma_z$;	
	$\sigma_x K$	$\begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	
	$\begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$-i\sigma_z$;	
	$\sigma_x K$	I	
	I	$i\sigma_z$;	
	$\sigma_x \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
	$I \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$-i\sigma_z \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$	
	$\sigma_y K$	$-\begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	$(+1, -1, +1)$
	$-\begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$i\sigma_z$;	
	$\sigma_y K$	$-\begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	
	$-\begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$-i\sigma_z$;	
	$\sigma_y K$	$-I$	
	$-I$	$-i\sigma_z$;	
	$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$-I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
	$-I \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$	
	$\sigma_y K$	$-I$	$(+1, -1, -1)$
	$-I$	I;	
	$\sigma_y K$	$-I$	
	$-I$	$-I$;	
	$\sigma_y K$	$-\begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	
	$-\begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	I;	
	$\sigma_y K$	$-\begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	
	$-\begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$-I$;	
	$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$-I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	

TABLE V. (*Continued.*)

$T_h \times Z_2^T$	T / C_{33}^+	C_{31}^- / $\mathcal{I}$	l.c.
	$-I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}}\\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2\\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}}\end{pmatrix}$	$I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$;	
	$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$-I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
	$-I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}}\\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2\\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}}\end{pmatrix}$	$-I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$	
	$\sigma_y \otimes \sigma_y K$	$I \otimes \begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	$(-1, +1, +1)$
	$-I \otimes \frac{\sqrt{3}}{3}\begin{pmatrix}e^{-i\frac{\pi}{6}} & \sqrt{2}i\\ \sqrt{2}i & e^{i\frac{\pi}{6}}\end{pmatrix}$	$-I \otimes I$;	
	$\sigma_y \otimes \sigma_y K$	$I \otimes \begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	
	$-I \otimes \frac{\sqrt{3}}{3}\begin{pmatrix}e^{-i\frac{\pi}{6}} & \sqrt{2}i\\ \sqrt{2}i & e^{i\frac{\pi}{6}}\end{pmatrix}$	$I \otimes I$;	
	$\sigma_x \otimes IK$	$\begin{pmatrix}1&0&0&0\\0&\omega^2&0&0\\0&0&1&0\\0&0&0&\omega\end{pmatrix}$	
	$\frac{\sqrt{3}}{3}\begin{pmatrix}i & \sqrt{2}e^{-i\frac{\pi}{6}} & 0 & 0\\ \sqrt{2}e^{-i\frac{\pi}{6}} & e^{i\frac{\pi}{6}} & 0 & 0\\ 0 & 0 & -i & \sqrt{2}e^{i\frac{\pi}{6}}\\ 0 & 0 & \sqrt{2}e^{i\frac{\pi}{6}} & e^{-i\frac{\pi}{6}}\end{pmatrix}$	$-I \otimes I$;	
	$\sigma_x \otimes IK$	$\begin{pmatrix}1&0&0&0\\0&\omega^2&0&0\\0&0&1&0\\0&0&0&\omega\end{pmatrix}$	
	$\frac{\sqrt{3}}{3}\begin{pmatrix}i & \sqrt{2}e^{-i\frac{\pi}{6}} & 0 & 0\\ \sqrt{2}e^{-i\frac{\pi}{6}} & e^{i\frac{\pi}{6}} & 0 & 0\\ 0 & 0 & -i & \sqrt{2}e^{i\frac{\pi}{6}}\\ 0 & 0 & \sqrt{2}e^{i\frac{\pi}{6}} & e^{-i\frac{\pi}{6}}\end{pmatrix}$	$I \otimes I$	
	$\sigma_y \otimes \sigma_y K$	$I \otimes \begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	$(-1, +1, -1)$
	$-I \otimes \frac{\sqrt{3}}{3}\begin{pmatrix}e^{-i\frac{\pi}{6}} & \sqrt{2}i\\ \sqrt{2}i & e^{i\frac{\pi}{6}}\end{pmatrix}$	$i\sigma_z \otimes I$;	
	$\sigma_x \otimes IK$	$\begin{pmatrix}1&0&0&0\\0&\omega^2&0&0\\0&0&1&0\\0&0&0&\omega\end{pmatrix}$	
	$\frac{\sqrt{3}}{3}\begin{pmatrix}i & \sqrt{2}e^{-i\frac{\pi}{6}} & 0 & 0\\ \sqrt{2}e^{-i\frac{\pi}{6}} & e^{i\frac{\pi}{6}} & 0 & 0\\ 0 & 0 & -i & \sqrt{2}e^{i\frac{\pi}{6}}\\ 0 & 0 & \sqrt{2}e^{i\frac{\pi}{6}} & e^{-i\frac{\pi}{6}}\end{pmatrix}$	$-i\sigma_z \otimes I$;	
	$\sigma_x \otimes IK$	$\begin{pmatrix}1&0&0&0\\0&\omega^2&0&0\\0&0&1&0\\0&0&0&\omega\end{pmatrix}$	$(-1, +1, -1)$
	$\frac{\sqrt{3}}{3}\begin{pmatrix}i & \sqrt{2}e^{-i\frac{\pi}{6}} & 0 & 0\\ \sqrt{2}e^{-i\frac{\pi}{6}} & e^{i\frac{\pi}{6}} & 0 & 0\\ 0 & 0 & -i & \sqrt{2}e^{i\frac{\pi}{6}}\\ 0 & 0 & \sqrt{2}e^{i\frac{\pi}{6}} & e^{-i\frac{\pi}{6}}\end{pmatrix}$	$i\sigma_z \otimes I$	
	$\sigma_x \otimes \sigma_y K$	$-I \otimes \begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	$(-1, -1, +1)$
	$I \otimes \frac{\sqrt{3}}{3}\begin{pmatrix}e^{-i\frac{\pi}{6}} & \sqrt{2}i\\ \sqrt{2}i & e^{i\frac{\pi}{6}}\end{pmatrix}$	$i\sigma_z \otimes I$;	
	$\sigma_y \otimes IK$	$-\begin{pmatrix}1&0&0&0\\0&\omega^2&0&0\\0&0&1&0\\0&0&0&\omega\end{pmatrix}$	
	$-\frac{\sqrt{3}}{3}\begin{pmatrix}i & \sqrt{2}e^{-i\frac{\pi}{6}} & 0 & 0\\ \sqrt{2}e^{-i\frac{\pi}{6}} & e^{i\frac{\pi}{6}} & 0 & 0\\ 0 & 0 & -i & \sqrt{2}e^{i\frac{\pi}{6}}\\ 0 & 0 & \sqrt{2}e^{i\frac{\pi}{6}} & e^{-i\frac{\pi}{6}}\end{pmatrix}$	$-i\sigma_z \otimes I$;	

TABLE V. (*Continued.*)

$T_h \times Z_2^T$	T	C_{31}^-	l.c.
	C_{33}^+	$\mathcal{I}$	
	$\sigma_y \otimes IK$	$-\begin{pmatrix} 1 & 0 & 0 & 0\\ 0 & \omega^2 & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & \omega \end{pmatrix}$	
	$-\frac{\sqrt{3}}{3}\begin{pmatrix} i & \sqrt{2}e^{-i\frac{\pi}{6}} & 0 & 0\\ \sqrt{2}e^{-i\frac{\pi}{6}} & e^{i\frac{\pi}{6}} & 0 & 0\\ 0 & 0 & -i & \sqrt{2}e^{i\frac{\pi}{6}}\\ 0 & 0 & \sqrt{2}e^{i\frac{\pi}{6}} & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$i\sigma_z \otimes I$	
	$\sigma_y K$	$-\begin{pmatrix} \omega & 0\\ 0 & \omega^2 \end{pmatrix}$	$(-1, -1, -1)$
	$\frac{\sqrt{3}}{3}\begin{pmatrix} e^{-i\frac{\pi}{6}} & \sqrt{2}i\\ \sqrt{2}i & e^{i\frac{\pi}{6}} \end{pmatrix}$	$-I$;	$(*)$
	$\sigma_y K$	$-\begin{pmatrix} \omega & 0\\ 0 & \omega^2 \end{pmatrix}$	
	$\frac{\sqrt{3}}{3}\begin{pmatrix} e^{-i\frac{\pi}{6}} & \sqrt{2}i\\ \sqrt{2}i & e^{i\frac{\pi}{6}} \end{pmatrix}$	I;	
	$\sigma_y \otimes IK$	$-\begin{pmatrix} 1 & 0 & 0 & 0\\ 0 & \omega^2 & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & \omega \end{pmatrix}$	
	$-\frac{\sqrt{3}}{3}\begin{pmatrix} i & \sqrt{2}e^{-i\frac{\pi}{6}} & 0 & 0\\ \sqrt{2}e^{-i\frac{\pi}{6}} & e^{i\frac{\pi}{6}} & 0 & 0\\ 0 & 0 & -i & \sqrt{2}e^{i\frac{\pi}{6}}\\ 0 & 0 & \sqrt{2}e^{i\frac{\pi}{6}} & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$I \otimes I$;	
	$\sigma_y \otimes IK$	$-\begin{pmatrix} 1 & 0 & 0 & 0\\ 0 & \omega^2 & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & \omega \end{pmatrix}$	
	$-\frac{\sqrt{3}}{3}\begin{pmatrix} i & \sqrt{2}e^{-i\frac{\pi}{6}} & 0 & 0\\ \sqrt{2}e^{-i\frac{\pi}{6}} & e^{i\frac{\pi}{6}} & 0 & 0\\ 0 & 0 & -i & \sqrt{2}e^{i\frac{\pi}{6}}\\ 0 & 0 & \sqrt{2}e^{i\frac{\pi}{6}} & e^{-i\frac{\pi}{6}} \end{pmatrix}$	$-I \otimes I$	

TABLE VI. The Reps of $O_h \times Z_2^T \simeq [(A_4 \rtimes Z_2) \times Z_2] \times Z_2^{\mathbb{T}}$. The symbols $\sigma_{x,y,z}$ are the three Pauli matrices, I is the 2×2 identity matrix, $\omega = e^{i\frac{2\pi}{3}}$, $\omega^{\frac{1}{2}} = e^{i\frac{\pi}{3}}$, l.c. denotes "label of classification", K stands for complex conjugation, $(*)$ labels the double valued Rep.

T	C_{31}^-	l.c.
C_{33}^+	C_{2f}	$\mathcal{I}$
K	1	$(+1, +1, +1, +1, +1)$
1	1	1;
K	1	
1	1	-1;
K	1	
1	-1	1;
K	1	
1	-1	-1;
$\sigma_x K$	$\begin{pmatrix} \omega & 0\\ 0 & \omega^2 \end{pmatrix}$	
$\begin{pmatrix} \omega^2 & 0\\ 0 & \omega \end{pmatrix}$	σ_x	$-I$;
$\sigma_x K$	$\begin{pmatrix} \omega & 0\\ 0 & \omega^2 \end{pmatrix}$	
$\begin{pmatrix} \omega^2 & 0\\ 0 & \omega \end{pmatrix}$	σ_x	I;
$\begin{pmatrix} 1 & 0 & 0\\ 0 & 0 & 1\\ 0 & 1 & 0 \end{pmatrix}K$	$\begin{pmatrix} 1 & 0 & 0\\ 0 & \omega^2 & 0\\ 0 & 0 & \omega \end{pmatrix}$	
$\frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}}\\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2\\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0\\ 0 & 0 & 1\\ 0 & 1 & 0 \end{pmatrix}$	$-\begin{pmatrix} 1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1 \end{pmatrix}$;

TABLE VI. (*Continued.*)

T	C_{31}^-	l.c.
C_{33}^+	C_{2f}	$\mathcal{I}$
$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$\begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$\frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$;
$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$\begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$\frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$-\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$-\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$;
$\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$\begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$\frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$-\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$
IK	I	$(+1, +1, +1, +1, -1)$
I	σ_x	σ_z;
$\sigma_x \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	
$I \otimes \begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	$I \otimes \sigma_x$	$\sigma_z \otimes \sigma_z$;
$I \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$I \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$\sigma_x \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$\sigma_z \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$
$\sigma_x K$	I	$(+1, +1, +1, -1, +1)$
$-I$	$i\sigma_z$	I;
$\sigma_x K$	I	
$-I$	$i\sigma_z$	$-I$;
$\sigma_x \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	
$-I \otimes \begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	$i\sigma_z \otimes \sigma_y$	$-I \otimes I$;
$\sigma_x \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	
$-I \otimes \begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	$i\sigma_z \otimes \sigma_y$	$I \otimes I$;
$\sigma_x \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$-I \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$-I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$;
$\sigma_x \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$-I \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$
IK	I	$(+1, +1, +1, -1, -1)$
$-I$	$i\sigma_y$	σ_z;
$\sigma_x \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	
$-I \otimes \begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	$i\sigma_z \otimes \sigma_y$	$\sigma_z \otimes \sigma_z$;
$I \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	

TABLE VI. (*Continued.*)

T	C_{31}^{-}	l.c.
C_{33}^{+}	C_{2f}	$\mathcal{I}$
$-I \otimes \frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}} \\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2 \\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$i\sigma_y \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$	$\sigma_z \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$
$\sigma_x K$	I	$(+1, +1, -1, +1, +1)$
I	$-I$	$i\sigma_z$;
$\sigma_x K$	I	
I	I	$i\sigma_z$;
$\sigma_x \otimes \sigma_x K$	$I \otimes \begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	
$I \otimes \begin{pmatrix} \omega^2 & 0 \\ 0 & \omega \end{pmatrix}$	$I \otimes \sigma_y$	$i\sigma_z \otimes I$;
$\sigma_x \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} K$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & \omega^2 & 0 \\ 0 & 0 & \omega \end{pmatrix}$	
$I \otimes \frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}} \\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2 \\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$-I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$;
$\sigma_x \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} K$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & \omega^2 & 0 \\ 0 & 0 & \omega \end{pmatrix}$	
$I \otimes \frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}} \\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2 \\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$
IK	I	$(+1, +1, -1, +1, -1)$
I	σ_z	$i\sigma_y$;
$\sigma_x K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	
$\begin{pmatrix} \omega^2 & 0 \\ 0 & \omega \end{pmatrix}$	σ_x	$i\sigma_z$;
$\sigma_x K$	$\begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	
$\begin{pmatrix} \omega^2 & 0 \\ 0 & \omega \end{pmatrix}$	σ_x	$-i\sigma_z$;
$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} K$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & \omega^2 & 0 \\ 0 & 0 & \omega \end{pmatrix}$	
$I \otimes \frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}} \\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2 \\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$\sigma_z \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$	$i\sigma_y \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$
$\sigma_x K$	I	$(+1, +1, -1, -1, +1)$
$-I$	$i\sigma_z$	$-i\sigma_z$;
$\sigma_x K$	I	
$-I$	$i\sigma_z$	$i\sigma_z$;
$\sigma_x \otimes \sigma_x K$	$I \otimes \begin{pmatrix} \omega & 0 \\ 0 & \omega^2 \end{pmatrix}$	
$-I \otimes \begin{pmatrix} \omega^2 & 0 \\ 0 & \omega \end{pmatrix}$	$i\sigma_z \otimes \sigma_x$	$i\sigma_z \otimes I$;
$\sigma_x \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} K$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & \omega^2 & 0 \\ 0 & 0 & \omega \end{pmatrix}$	
$-I \otimes \frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}} \\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2 \\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$-i\sigma_z \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$;
$\sigma_x \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} K$	$I \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & \omega^2 & 0 \\ 0 & 0 & \omega \end{pmatrix}$	$(+1, +1, -1, -1, +1)$
$-I \otimes \frac{1}{3}\begin{pmatrix} -1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}} \\ 2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2 \\ 2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}} \end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$
$\sigma_x \otimes \sigma_x K$	$I \otimes I$	$(+1, +1, -1, -1, -1)$
$-I \otimes I$	$iI \otimes \sigma_z$	$i\sigma_z \otimes \sigma_y$;

TABLE VI. (*Continued.*)

T	C_{31}^{-}	l.c.
C_{33}^{+}	C_{2f}	$\mathcal{I}$
$\sigma_x \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega & 0\\0 & \omega^2\end{pmatrix}$	
$-I \otimes \begin{pmatrix}\omega^2 & 0\\0 & \omega\end{pmatrix}$	$i\sigma_z \otimes \sigma_y$	$-iI \otimes \sigma_z$;
$\sigma_x \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega & 0\\0 & \omega^2\end{pmatrix}$	
$-I \otimes \begin{pmatrix}\omega^2 & 0\\0 & \omega\end{pmatrix}$	$i\sigma_z \otimes \sigma_y$	$iI \otimes \sigma_z$;
$(\sigma_x \otimes \sigma_x) \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix} K$	$(I \otimes I) \otimes \begin{pmatrix}1 & 0 & 0\\0 & \omega^2 & 0\\0 & 0 & \omega\end{pmatrix}$	
$-(I \otimes I) \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2\\2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}}\end{pmatrix}$	$(iI \otimes \sigma_z) \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix}$	$(i\sigma_z \otimes \sigma_y) \otimes \begin{pmatrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{pmatrix}$
$\sigma_y K$	I	$(+1, -1, +1, +1, +1)$
$-I$	$i\sigma_z$	$-i\sigma_z$;
$\sigma_y K$	I	
$-I$	$i\sigma_z$	$i\sigma_z$;
$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega & 0\\0 & \omega^2\end{pmatrix}$	
$-I \otimes \begin{pmatrix}\omega^2 & 0\\0 & \omega\end{pmatrix}$	$i\sigma_z \otimes \sigma_y$	$i\sigma_z \otimes I$;
$\sigma_y \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix} K$	$I \otimes \begin{pmatrix}1 & 0 & 0\\0 & \omega^2 & 0\\0 & 0 & \omega\end{pmatrix}$	
$-I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2\\2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}}\end{pmatrix}$	$-i\sigma_z \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{pmatrix}$;
$\sigma_y \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix} K$	$I \otimes \begin{pmatrix}1 & 0 & 0\\0 & \omega^2 & 0\\0 & 0 & \omega\end{pmatrix}$	
$-I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2\\2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}}\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{pmatrix}$
$\sigma_y K$	I	$(+1, -1, +1, +1, -1)$
$-I$	$i\sigma_z$	$i\sigma_y$;
$\sigma_y K$	$\begin{pmatrix}\omega & 0\\0 & \omega^2\end{pmatrix}$	
$-\begin{pmatrix}\omega^2 & 0\\0 & \omega\end{pmatrix}$	$i\sigma_y$	$-i\sigma_z$;
$\sigma_y K$	$\begin{pmatrix}\omega & 0\\0 & \omega^2\end{pmatrix}$	
$-\begin{pmatrix}\omega^2 & 0\\0 & \omega\end{pmatrix}$	$i\sigma_y$	$i\sigma_z$;
$\sigma_y \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix} K$	$I \otimes \begin{pmatrix}1 & 0 & 0\\0 & \omega^2 & 0\\0 & 0 & \omega\end{pmatrix}$	$(+1, -1, +1, +1, -1)$
$-I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2\\2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}}\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix}$	$-i\sigma_x \otimes \begin{pmatrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{pmatrix}$
$\sigma_y K$	I	$(+1, -1, +1, -1, +1)$
I	$-I$	$i\sigma_z$;
$\sigma_y K$	I	
I	I	$i\sigma_z$;
$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega & 0\\0 & \omega^2\end{pmatrix}$	
$I \otimes \begin{pmatrix}\omega^2 & 0\\0 & \omega\end{pmatrix}$	$I \otimes \sigma_y$	$i\sigma_z \otimes I$;
$\sigma_y \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix} K$	$I \otimes \begin{pmatrix}1 & 0 & 0\\0 & \omega^2 & 0\\0 & 0 & \omega\end{pmatrix}$	
$I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac{1}{2}} & 2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}} & \omega^{-\frac{1}{2}} & 2\\2\omega^{-\frac{1}{2}} & 2 & \omega^{\frac{1}{2}}\end{pmatrix}$	$-I \otimes \begin{pmatrix}1 & 0 & 0\\0 & 0 & 1\\0 & 1 & 0\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{pmatrix}$;

TABLE VI. (*Continued.*)

T	C_{31}^-	l.c.
C_{33}^+	C_{2f}	$\mathcal{I}$
$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$I \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$I \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$
$\sigma_y \otimes \sigma_x K$	$I \otimes I$	$(+1, -1, +1, -1, -1)$
$I \otimes I$	$\sigma_z \otimes \sigma_z$	$i\sigma_z \otimes \sigma_y$;
$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	
$I \otimes \begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	$I \otimes \sigma_x$	$iI \otimes \sigma_z$;
$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	
$I \otimes \begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	$I \otimes \sigma_x$	$-iI \otimes \sigma_z$;
$(\sigma_y \otimes \sigma_x) \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$(I \otimes I) \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$(I \otimes I) \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$(\sigma_z \otimes \sigma_z) \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$(i\sigma_z \otimes \sigma_y) \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$
$\sigma_y K$	I	$(+1, -1, -1, +1, +1)$
$-I$	$i\sigma_z$	I;
$\sigma_y K$	I	
$-I$	$i\sigma_z$	$-I$;
$\sigma_y K$	$\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	
$-\begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	$i\sigma_y$	$-I$;
$\sigma_y K$	$\begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	
$-\begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	$i\sigma_y$	I;
$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$-I \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$-I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$;
$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	$(+1, -1, -1, +1, +1)$
$-I \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$i\sigma_z \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$
$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega&0\\0&\omega^2\end{pmatrix}$	$(+1, -1, -1, +1, -1)$
$-I \otimes \begin{pmatrix}\omega^2&0\\0&\omega\end{pmatrix}$	$i\sigma_z \otimes \sigma_y$	$\sigma_z \otimes \sigma_z$;
$\sigma_y \otimes \sigma_x K$	$I \otimes I$	
$-I \otimes I$	$i\sigma_z \otimes \sigma_y$	$\sigma_z \otimes \sigma_z$;
$(\sigma_y \otimes I) \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$(I \otimes I) \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$-(I \otimes I) \otimes \frac{1}{3}\begin{pmatrix}-1&2\omega^{\frac{1}{2}}&2\omega^{-\frac{1}{2}}\\2\omega^{\frac{1}{2}}&\omega^{-\frac{1}{2}}&2\\2\omega^{-\frac{1}{2}}&2&\omega^{\frac{1}{2}}\end{pmatrix}$	$(iI \otimes \sigma_y) \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$(I \otimes \sigma_z) \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$
$\sigma_y K$	I	$(+1, -1, -1, -1, +1)$
I	$-I$	$-I$;
$\sigma_y K$	I	
I	$-I$	I;

TABLE VI. (*Continued*.)

T	C_{31}^-	l.c.
C_{33}^+	C_{2f}	$\mathcal{I}$
$\sigma_y K$	I	
I	I	$-I$;
$\sigma_y K$	I	
I	I	I;
$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	
$I \otimes \begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$I \otimes \sigma_y$	$-I \otimes I$;
$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	
$I \otimes \begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$I \otimes \sigma_y$	$I \otimes I$;
$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac12} & 2\omega^{-\frac12}\\ 2\omega^{\frac12} & \omega^{-\frac12} & 2\\ 2\omega^{-\frac12} & 2 & \omega^{\frac12}\end{pmatrix}$	$I \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$-I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$;
$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac12} & 2\omega^{-\frac12}\\ 2\omega^{\frac12} & \omega^{-\frac12} & 2\\ 2\omega^{-\frac12} & 2 & \omega^{\frac12}\end{pmatrix}$	$I \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$;
$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac12} & 2\omega^{-\frac12}\\ 2\omega^{\frac12} & \omega^{-\frac12} & 2\\ 2\omega^{-\frac12} & 2 & \omega^{\frac12}\end{pmatrix}$	$-I \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$-I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$;
$\sigma_y \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$I \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	$(+1, -1, -1, -1, +1)$
$I \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac12} & 2\omega^{-\frac12}\\ 2\omega^{\frac12} & \omega^{-\frac12} & 2\\ 2\omega^{-\frac12} & 2 & \omega^{\frac12}\end{pmatrix}$	$-I \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$I \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$
$\sigma_y \otimes \sigma_x K$	$I \otimes \begin{pmatrix}\omega & 0\\ 0 & \omega^2\end{pmatrix}$	$(+1, -1, -1, -1, -1)$
$I \otimes \begin{pmatrix}\omega^2 & 0\\ 0 & \omega\end{pmatrix}$	$I \otimes \sigma_y$	$\sigma_z \otimes \sigma_z$;
$\sigma_y \otimes \sigma_x K$	$I \otimes I$	
$I \otimes I$	$I \otimes \sigma_y$	$-\sigma_z \otimes \sigma_z$;
$(\sigma_y \otimes I) \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}K$	$(I \otimes I) \otimes \begin{pmatrix}1&0&0\\0&\omega^2&0\\0&0&\omega\end{pmatrix}$	
$(I \otimes I) \otimes \frac{1}{3}\begin{pmatrix}-1 & 2\omega^{\frac12} & 2\omega^{-\frac12}\\ 2\omega^{\frac12} & \omega^{-\frac12} & 2\\ 2\omega^{-\frac12} & 2 & \omega^{\frac12}\end{pmatrix}$	$(I \otimes \sigma_x) \otimes \begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}$	$(I \otimes \sigma_z) \otimes \begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$
$\sigma_y \otimes \sigma_y K$	$I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix}e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	$(-1, +1, +1, +1, +1)$
$-I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix}e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$-\sigma_z \otimes \sigma_y$	$-I \otimes I$;
$\sigma_y \otimes \sigma_y K$	$I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix}e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	
$-I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix}e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$-\sigma_z \otimes \sigma_y$	$I \otimes I$;
$\sigma_x \otimes I K$	$-\frac{\sqrt{2}}{4}\begin{pmatrix}e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}}\\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3}\\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1\\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}}\end{pmatrix}$	
$\frac{\sqrt{2}}{4}\begin{pmatrix}e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}}\\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3}\\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1\\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}}\end{pmatrix}$	$-I \otimes \sigma_x$	$I \otimes I$;

TABLE VI. (*Continued*.)

T	C_{31}^-	l.c.
C_{33}^+	C_{2f}	$\mathcal{I}$
$\sigma_x\otimes IK$	$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$I\otimes\sigma_x$	$-I\otimes I$
$(\sigma_x\otimes\sigma_x)\otimes IK$	$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{12}} & e^{-i\frac{\pi}{6}} & 0 & 0 \\ e^{-i\frac{\pi}{6}} & e^{i\frac{7\pi}{12}} & 0 & 0 \\ 0 & 0 & e^{-i\frac{\pi}{12}} & e^{i\frac{\pi}{6}} \\ 0 & 0 & e^{i\frac{\pi}{6}} & e^{-i\frac{7\pi}{12}} \end{pmatrix}$	$(-1,+1,+1,+1,-1)$
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{7\pi}{12}} & \omega & 0 & 0 \\ -\omega & e^{-i\frac{\pi}{12}} & 0 & 0 \\ 0 & 0 & e^{i\frac{7\pi}{12}} & \omega^2 \\ 0 & 0 & -\omega^2 & e^{i\frac{\pi}{12}} \end{pmatrix}$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} 0 & 0 & e^{-i\frac{\pi}{12}} & e^{i\frac{\pi}{6}} \\ 0 & 0 & e^{i\frac{\pi}{6}} & e^{-i\frac{7\pi}{12}} \\ e^{i\frac{\pi}{12}} & e^{-i\frac{\pi}{6}} & 0 & 0 \\ e^{-i\frac{\pi}{6}} & e^{i\frac{7\pi}{12}} & 0 & 0 \end{pmatrix}$	$(\sigma_z\otimes\sigma_z)\otimes I;$
$(\sigma_y\otimes\sigma_x)\otimes\sigma_y K$	$(I\otimes I)\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1,+1,+1,+1,-1)$
$-(I\otimes I)\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & 1 \\ -1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-\sigma_z\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} 0 & 0 & e^{i\frac{\pi}{4}} & 1 \\ 0 & 0 & i & -e^{i\frac{\pi}{4}} \\ e^{-i\frac{\pi}{4}} & -i & 0 & 0 \\ 1 & -e^{-i\frac{\pi}{4}} & 0 & 0 \end{pmatrix}$	$(\sigma_z\otimes\sigma_z)\otimes I$
$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1,+1,+1,-1,+1)$
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-iI\otimes\sigma_y$	$-I\otimes I;$
$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-iI\otimes\sigma_y$	$I\otimes I;$
$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$iI\otimes\sigma_y$	$-I\otimes I;$
$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$iI\otimes\sigma_y$	$I\otimes I;$
$(\sigma_y\otimes I)\otimes\sigma_y K$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(iI\otimes I)\otimes\sigma_x$	$-(I\otimes I)\otimes I;$
$(\sigma_y\otimes I)\otimes\sigma_y K$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(iI\otimes I)\otimes\sigma_x$	$(I\otimes I)\otimes I$
$(\sigma_x\otimes\sigma_x)\otimes IK$	$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{12}} & e^{i\frac{5\pi}{6}} & 0 & 0 \\ e^{i\frac{5\pi}{6}} & e^{i\frac{7\pi}{12}} & 0 & 0 \\ 0 & 0 & e^{-i\frac{\pi}{12}} & e^{-i\frac{5\pi}{6}} \\ 0 & 0 & e^{-i\frac{5\pi}{6}} & e^{-i\frac{7\pi}{12}} \end{pmatrix}$	$(-1,+1,+1,-1,-1)$

TABLE VI. (*Continued.*)

T	C_{31}^-	l.c.
C_{33}^+	C_{2f}	$\mathcal{I}$
$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{7\pi}{12}} & -\omega & 0 & 0\\ \omega & e^{-i\frac{\pi}{12}} & 0 & 0\\ 0 & 0 & e^{i\frac{7\pi}{12}} & -\omega^2\\ 0 & 0 & \omega^2 & e^{i\frac{\pi}{12}}\end{pmatrix}$	$\sigma_z\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} 0 & 0 & e^{i\frac{5\pi}{12}} & -\omega\\ 0 & 0 & -\omega & e^{-i\frac{\pi}{12}}\\ -e^{-i\frac{5\pi}{12}} & \omega^2 & 0 & 0\\ \omega^2 & -e^{i\frac{\pi}{12}} & 0 & 0\end{pmatrix}$	$(\sigma_z\otimes\sigma_z)\otimes I;$
$(\sigma_y\otimes\sigma_x)\otimes\sigma_y K$	$(I\otimes I)\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	
$(I\otimes I)\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & 1\\ -1 & e^{i\frac{\pi}{4}}\end{pmatrix}$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} 0 & 0 & -e^{i\frac{\pi}{4}} & -1\\ 0 & 0 & -i & e^{i\frac{\pi}{4}}\\ e^{-i\frac{\pi}{4}} & -i & 0 & 0\\ 1 & -e^{-i\frac{\pi}{4}} & 0 & 0\end{pmatrix}$	$(\sigma_z\otimes\sigma_z)\otimes I$
$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	$(-1,+1,-1,+1,+1)$
$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$-\sigma_z\otimes\sigma_y$	$i\sigma_z\otimes I;$
$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	
$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$-\sigma_z\otimes\sigma_y$	$-i\sigma_z\otimes I;$
$(\sigma_y\otimes I)\otimes\sigma_y K$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}}\\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3}\\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1\\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}}\end{pmatrix}$	
$I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}}\\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3}\\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1\\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}}\end{pmatrix}$	$(\sigma_z\otimes I)\otimes\sigma_x$	$(-i\sigma_z\otimes I)\otimes I$
$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	$(-1,+1,-1,+1,-1)$
$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$\sigma_z\otimes\sigma_y$	$-i\sigma_x\otimes I;$
$\sigma_x\otimes IK$	$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}}\\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3}\\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1\\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}}\end{pmatrix}$	
$\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}}\\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3}\\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1\\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}}\end{pmatrix}$	$-I\otimes\sigma_x$	$-i\sigma_x\otimes\sigma_y;$
$\sigma_x\otimes IK$	$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}}\\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3}\\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1\\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}}\end{pmatrix}$	
$\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}}\\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3}\\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1\\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}}\end{pmatrix}$	$I\otimes\sigma_x$	$i\sigma_x\otimes\sigma_y$
$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	$(-1,+1,-1,-1,+1)$
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$-iI\otimes\sigma_y$	$-i\sigma_z\otimes I;$
$\sigma_y\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i\\ i & e^{i\frac{\pi}{4}}\end{pmatrix}$	
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i\\ i & e^{-i\frac{\pi}{4}}\end{pmatrix}$	$iI\otimes\sigma_y$	$-i\sigma_z\otimes I;$
$(\sigma_x\otimes\sigma_x)\otimes IK$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}}\\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3}\\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1\\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}}\end{pmatrix}$	

TABLE VI. (*Continued*.)

T	C_{31}^{-}	l.c.
C_{33}^{+}	C_{2f}	$\mathcal{I}$
$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(i\sigma_z\otimes I)\otimes\sigma_x$	$(-i\sigma_z\otimes I)\otimes I$
$(\sigma_y\otimes\sigma_x)\otimes\sigma_y K$	$(I\otimes I)\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1,+1,-1,-1,-1)$
$(I\otimes I)\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$(i\sigma_z\otimes\sigma_z)\otimes\sigma_y$	$(\sigma_z\otimes i\sigma_y)\otimes I$;
$(\sigma_y\otimes I)\otimes\sigma_y K$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(I\otimes I)\otimes i\sigma_x$	$-(I\otimes i\sigma_x)\otimes\sigma_y$;
$(\sigma_y\otimes I)\otimes\sigma_y K$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$(-1,+1,-1,-1,-1)$
$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-(I\otimes I)\otimes i\sigma_x$	$(I\otimes i\sigma_x)\otimes\sigma_y$
$\sigma_x\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1,-1,+1,+1,+1)$
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-iI\otimes\sigma_y$	$-i\sigma_z\otimes I$;
$\sigma_x\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$iI\otimes\sigma_y$	$-i\sigma_z\otimes I$;
$(\sigma_x\otimes I)\otimes\sigma_y K$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-iI\otimes I)\otimes\sigma_x$	$(-i\sigma_z\otimes I)\otimes I$
$I\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1,-1,+1,+1,-1)$
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_z\otimes\sigma_y$	$i\sigma_y\otimes I$;
$I\otimes\sigma_y K$	$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-I\otimes i\sigma_x$	$-i\sigma_x\otimes\sigma_y$;
$I\otimes\sigma_y K$	$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-I\otimes i\sigma_x$	$i\sigma_x\otimes\sigma_y$

TABLE VI. (*Continued.*)

T	C_{31}^-	l.c.
C_{33}^+	C_{2f}	$\mathcal{I}$
$\sigma_x \otimes \sigma_y K$	$I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1, -1, +1, -1, +1)$
$-I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$\sigma_z \otimes \sigma_y$	$-i\sigma_z \otimes I;$
$\sigma_x \otimes \sigma_y K$	$I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1, -1, +1, -1, +1)$
$-I \otimes \frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$\sigma_z \otimes \sigma_y$	$i\sigma_z \otimes I;$
$(\sigma_y \otimes \sigma_x) \otimes IK$	$-I \otimes \frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$I \otimes \frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(I \otimes I) \otimes \sigma_x$	$(-i\sigma_z \otimes I) \otimes I$
$(\sigma_y \otimes \sigma_y) \otimes \sigma_y K$	$(I \otimes I) \otimes \frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1, -1, +1, -1, -1)$
$-(I \otimes I) \otimes \frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-(I \otimes \sigma_z) \otimes \sigma_y$	$-(I \otimes i\sigma_y) \otimes I;$
$(\sigma_y \otimes \sigma_x) \otimes IK$	$-I \otimes \frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$I \otimes \frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(I \otimes I) \otimes \sigma_x$	$-(I \otimes i\sigma_x) \otimes \sigma_y;$
$(\sigma_y \otimes \sigma_x) \otimes IK$	$-I \otimes \frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$I \otimes \frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-(I \otimes I) \otimes \sigma_x$	$(I \otimes i\sigma_x) \otimes \sigma_y$
$\sigma_y K$	$\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1, -1, -1, +1, +1)$
$\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-i\sigma_y$	$-I;$
$\sigma_y K$	$\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(*)$
$\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-i\sigma_y$	$I;$
$\sigma_y K$	$\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	
$\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_y$	$-I;$
$\sigma_y K$	$\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	
$\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$i\sigma_y$	$I;$
$I \otimes \sigma_y K$	$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$(-1, -1, -1, +1, +1)$
$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-iI \otimes \sigma_x$	$I \otimes I;$

TABLE VI. (*Continued.*)

T	C_{31}^{-}	l.c.
C_{33}^{+}	C_{2f}	$\mathcal{I}$
$I\otimes\sigma_y K$	$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$(*)$
$-\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-iI\otimes\sigma_x$	$-I\otimes I$
$(\sigma_y\otimes\sigma_x)\otimes IK$	$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{12}} & e^{i\frac{5\pi}{6}} & 0 & 0 \\ e^{i\frac{5\pi}{6}} & e^{i\frac{7\pi}{12}} & 0 & 0 \\ 0 & 0 & e^{-i\frac{\pi}{12}} & e^{-i\frac{5\pi}{6}} \\ 0 & 0 & e^{-i\frac{5\pi}{6}} & e^{-i\frac{7\pi}{12}} \end{pmatrix}$	$(-1,-1,-1,+1,-1)$
$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{7\pi}{12}} & -\omega & 0 & 0 \\ \omega & e^{-i\frac{\pi}{12}} & 0 & 0 \\ 0 & 0 & e^{i\frac{7\pi}{12}} & -\omega^2 \\ 0 & 0 & \omega^2 & e^{i\frac{\pi}{12}} \end{pmatrix}$	$\sigma_z\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} 0 & 0 & e^{i\frac{\pi}{6}} & e^{-i\frac{7\pi}{12}} \\ 0 & 0 & e^{-i\frac{7\pi}{12}} & -\omega \\ e^{i\frac{5\pi}{6}} & e^{-i\frac{5\pi}{12}} & 0 & 0 \\ e^{-i\frac{5\pi}{12}} & \omega^2 & 0 & 0 \end{pmatrix}$	$(\sigma_z\otimes\sigma_z)\otimes I$;
$I\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & 1 \\ -1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$\sigma_x\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} i & e^{i\frac{\pi}{4}} \\ -e^{-i\frac{\pi}{4}} & -i \end{pmatrix}$	$\sigma_z\otimes I$
$\sigma_x\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(-1,-1,-1,-1,+1)$
$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-\sigma_z\otimes\sigma_y$	$-I\otimes I$;
$\sigma_x\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	
$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{4}} & i \\ i & e^{-i\frac{\pi}{4}} \end{pmatrix}$	$-\sigma_z\otimes\sigma_y$	$I\otimes I$;
$(\sigma_x\otimes I)\otimes\sigma_y K$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$(\sigma_z\otimes I)\otimes\sigma_x$	$(I\otimes I)\otimes I$;
$(\sigma_x\otimes I)\otimes\sigma_y K$	$-I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{-i\frac{\pi}{4}} & -1 & -\sqrt{3} & -\sqrt{3}e^{-i\frac{\pi}{4}} \\ 1 & e^{i\frac{\pi}{4}} & \sqrt{3}e^{i\frac{\pi}{4}} & -\sqrt{3} \\ -\sqrt{3} & -\sqrt{3}e^{i\frac{\pi}{4}} & e^{i\frac{\pi}{4}} & -1 \\ \sqrt{3}e^{-i\frac{\pi}{4}} & -\sqrt{3} & 1 & e^{-i\frac{\pi}{4}} \end{pmatrix}$	
$I\otimes\frac{\sqrt{2}}{4}\begin{pmatrix} e^{i\frac{\pi}{4}} & -1 & \sqrt{3} & \sqrt{3}e^{i\frac{\pi}{4}} \\ 1 & e^{-i\frac{\pi}{4}} & -\sqrt{3}e^{-i\frac{\pi}{4}} & \sqrt{3} \\ \sqrt{3} & \sqrt{3}e^{-i\frac{\pi}{4}} & e^{-i\frac{\pi}{4}} & -1 \\ -\sqrt{3}e^{i\frac{\pi}{4}} & \sqrt{3} & 1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-(\sigma_z\otimes I)\otimes\sigma_x$	$-(I\otimes I)\otimes I$
$(\sigma_y\otimes\sigma_x)\otimes IK$	$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{i\frac{\pi}{12}} & e^{-i\frac{\pi}{6}} & 0 & 0 \\ e^{-i\frac{\pi}{6}} & e^{i\frac{7\pi}{12}} & 0 & 0 \\ 0 & 0 & e^{-i\frac{\pi}{12}} & e^{i\frac{\pi}{6}} \\ 0 & 0 & e^{i\frac{\pi}{6}} & e^{-i\frac{7\pi}{12}} \end{pmatrix}$	$(-1,-1,-1,-1,-1)$
$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{7\pi}{12}} & \omega & 0 & 0 \\ -\omega & e^{-i\frac{\pi}{12}} & 0 & 0 \\ 0 & 0 & e^{i\frac{7\pi}{12}} & \omega^2 \\ 0 & 0 & -\omega^2 & e^{i\frac{\pi}{12}} \end{pmatrix}$	$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} 0 & 0 & e^{i\frac{5\pi}{12}} & \omega \\ 0 & 0 & \omega & e^{-i\frac{\pi}{12}} \\ e^{-i\frac{5\pi}{12}} & \omega^2 & 0 & 0 \\ \omega^2 & e^{i\frac{\pi}{12}} & 0 & 0 \end{pmatrix}$	$(\sigma_z\otimes\sigma_z)\otimes I$;
$I\otimes\sigma_y K$	$I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & i \\ i & e^{i\frac{\pi}{4}} \end{pmatrix}$	
$-I\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} e^{-i\frac{\pi}{4}} & 1 \\ -1 & e^{i\frac{\pi}{4}} \end{pmatrix}$	$-i\sigma_y\otimes\frac{\sqrt{2}}{2}\begin{pmatrix} i & e^{i\frac{\pi}{4}} \\ -e^{-i\frac{\pi}{4}} & -i \end{pmatrix}$	$\sigma_z\otimes I$

the other has linear dispersion k_z and quadratic dispersion $[k_zk_x, k_zk_y]$. Both the two 4-dim Reps have nodal lines in the directions of $k_y, k_{\sqrt{3}x\pm y}$.

For $G_0(\boldsymbol{k}) = D^1_{3h} \times Z^{\tilde{T}}_2$, class $(-1, -1, -1, -1)$ has two inequivalent 4-dim IPReps, one has linear dispersion k_z, the other has linear dispersion k_z and quadratic dispersion $[k_zk_x, k_zk_y]$. Both the two 4-dim Reps have nodal lines in the directions of $k_x, k_{x\pm\sqrt{3}y}$.

For $G_0(\boldsymbol{k}) = O_h \times Z^T_2$, class $(-1, +1, -1, +1, -1)$ has three inequivalent 4-dim IPReps, one has quadratic dispersion $[k_xk_y, k_xk_z, k_yk_z]$ and cubic dispersion $k_xk_yk_z$, the other two have quadratic dispersion $[k_xk_y, k_xk_z, k_yk_z]$. All the three 4-dim Reps have nodal lines in the directions of k_x, k_y, k_z.

For $G_0(\boldsymbol{k}) = O_h \times Z^T_2$, class $(-1, +1, -1, +1, +1)$ has one 8-dim irreducible Rep and two 4-dim irreducible Reps. The 8-dim Rep has linear dispersion $[k_x, k_y, k_z]$, but no nodal lines. The two 4-dim Reps have cubic dispersion $k_xk_yk_z$ and nodal lines in the directions of $k_x, k_y, k_z, k_{x\pm y}, k_{x\pm z}, k_{y\pm z}$.

For $G_0(\boldsymbol{k}) = D^3_3 \times Z^{\tilde{T}}_2$, class $(-1, -1)$ has one 4-dim IPRep, it has linear dispersions in the direction of k_{x+y+z} and the plane $k^{\perp}_{x+y+z}$, which is perpendicular to k_{x+y+z}.

For $G_0(\boldsymbol{k}) = D^3_{3d} \times Z^T_2$, class $(+1, +1, -1, +1)$ has one 4-dim IPRep, it has linear dispersion in the direction of k_{x+y+z} and quadratic dispersion $(k^{\perp}_{x+y+z})^2$ in the plane perpendicular to k_{x+y+z}.

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