TABLE I.

Line[3]	Schüler (exp.)	Güttinger	$i=1\frac{1}{2}$ Extreme coupling	$i=1\frac{1}{2}$ Intermed. coupling	$i=\frac{1}{2}$ Intermed. coupling
1	(0.5) 18231.31	(1) 31.31	31.31	31.31	
2	(1) 30.91	(2) 30.91	30.91	30.91	(1) 30.91
3	(2) 30.26	(3) 30.25	30.26	30.26	(2) 30.26
4c		(2) 27.82	27.79	27.83−x	
4b	(6) 27.72	(5.5) 27.74	27.88	27.97−3.1x	(5) 27.56
4a		(2) 27.62	27.69	27.70−x	
5b	(12) 27.52	(11) 27.56	27.58	27.58−x	(9) 27.39
5a		(3) 27.42	27.48	27.57−3.1x	
6c		(.5) 27.22	27.29	27.30−x	
6b	(2) 27.15	(2.5) 27.10	27.14	27.18−x	(1) 26.91
8c		(2) 25.96	26.03	26.12	
8b	(6) 25.91	(2.5) 25.89	25.94	25.91−x	(1) 25.80
13b		(.7) 25.56	25.63	25.72	
13a	(1.5) 25.46	(2) 25.36	25.44	25.44−x	(2) 25.51
9	(4) 25.25	(5.5) 25.23	25.29	25.26−x	(5) 25.15
10	(1) 24.93	(2.5) 24.90	24.98	25.07	(1) 24.86

would bring much better agreement than was found in Güttinger's approximation. In the case $i=\frac{1}{2}$, our results give agreement just slightly worse than those quoted by Schüler.

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[3] The components 7, 11 and 14 are attributed to the Li^6 isotope and have been omitted in this table. They are at 26.43, 24.33 and 29.48.

An Attempt to Detect Axiality of X-Ray Emission

J. Stark[1] has recently reported that fluorescent *K*-series x-rays are not emitted with equal intensity in all directions from certain crystals, and that these x-rays are at least partially plane-polarized. In the case of γ-γ-dibromoanthracene, a monoclinic crystal of needle-like habit with the *b*-axis parallel to the length of the needle, he found about 20 percent more bromine *K*-radiation in directions 90° from the *b*-axis than in a direction 10° therefrom. The scattering of this radiation by aluminium indicated that it was polarized with the electric vector parallel to the *b*-axis. These effects are so important from the theoretical side that independent confirmation seemed desirable. This note reports an unsuccessful attempt to detect differences in the intensity of zinc *K*-radiation emitted in different crystallographic directions from a zinc crystal.

Zinc was chosen because the axial ratio for its hexagonal crystals, $c/a=1.86$, is so much greater than that (1.63) to be expected in a close-packed arrangement of spheres that it is reasonable to suppose the atomic axes are not free to rotate about axes in the (001) plane. This is one of the criteria suggested by Stark for selecting materials likely to show the new effect. His objection to the use of metals, that the atoms therein are presumably free to rotate, does not therefore seem valid with respect to zinc.

The primary x-rays used were from a tungsten target tube operated at 55000 volts (peak) or from a molybdenum target tube operated at 44000 volts (peak). The zinc monocrystalline plate, 0.4 cm thick was rotated about its normal into various azimuths while its secondary radiation in a fixed direction 90° from the primary beam was measured by balancing its ionization with that of part of the primary beam. The absorption coefficient of the secondary radiation was found to be that of zinc *K*-radiation, indicating that the scattered radiation at 90° was negligible in comparison with the fluorescent. The normal to the plate was found by Laue and rotation

[1] Stark, Ann. d. Physik [5] 6, 637–662 (1930).

photographs to lie at 20° from the hexagonal axis of the crystal, so that if θ is the angle between the normal and the axis of the principal ionization chamber the angles between this axis and the hexagonal axis of the crystal vary between $\theta+20°$ and $\theta-20°$ during the rotation of the specimen. For the three settings tested, θ was 52°, 62° and 77°. In no case was the variation in observed intensity as much as one percent. We conclude that at least as regards intensity the effect reported by Stark is unimportant in zinc.

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Rotational Fine Structure in Raman Spectra

In recording the rotation spectrum of a molecule by scattered light one of the major difficulties is the very great intensity of the unmodified line as compared with those lines arising from changes in rotational energy. Long exposures tend to broaden the strong line and obliterate the weaker ones which lie very close to it. An ingenious arrangement employed by Rasetti (Zeits. f. Physik **66,** 646 (1930)) is partially effective in overcoming this handicap. He introduced mercury vapor into the spectrograph to absorb from the scattered light those unmodified frequencies which arise from the normal state of the atom. The observations are thus practically confined to λ2537 as parent line. Even this expedient is not wholly successful, since λ2535 is superposed upon the rotation pattern and appears very intense in comparison with it.

Recently Manneback (Zeits. f. Physik **62,** 224 (1930)) has computed the relative intensities and polarizations for Raleigh and Raman scattering of lines with and without rotational displacements. He shows that if the incident light is plane polarized and the scattered light is observed in a plane normal to the electric vector, the rotation lines are almost completely depolarized. Since the unmodified line is not depolarized, this suggests the introduction of a Nicol prism between the camera and the scattering chamber. Any convenient source and any frequency for the incident line could then be used, and not only the parent line but also neighboring lines scattered without change in frequency would be eliminated. In all probability the background illumination would also be materially lessened. With this improvement in contrast considerably smaller total exposures should prove adequate, and the necessary time might not be much extended, even though the illumination would be considerably fainter.

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January 28, 1931.

Biological Effects of Gamma-Rays

In connection with the development in various laboratories of x-ray tubes operating at voltages of the order of a million volts, the question of adequate protection of those engaged in the work against the very penetrating gamma-rays emitted by such tubes has become of considerable importance. It has seemed valuable to perform some experiments with highly filtered gamma-rays from radium in order to ascertain the dangers from exposure to the penetrating radiation, which may be considerable in amount, passing through whatever shielding may be used around the tube. Estimates doubtless might be made from previous work, but for comparison it appeared desirable to have data on exposures to gamma-rays from radium from which all soft components were similarly filtered out.

A group of 63 white rats (with known antecedents) has been exposed to the radiation from 6 grams of radium filtered through one mm of platinum, one mm of brass, 16 mm of lead, and 5 mm of celluloid at a distance of 41 mm to the nearest side of the rat. For four additional rats the celluloid was omitted. The rats were put in celluloid boxes 47 mm high placed above and below the radium box. The radium was spread out over a surface of 3 by 10 cm area to give more uniform exposure. With this large source-area and distance, the exposure was reasonably similar throughout the whole body of the rat. In addition, 16 rats were exposed to 2.5 grams of radium at the same distance but with the lead filter removed; for eight of this group the celluloid was also omitted. This group of 16 thus re-