

Since the sum of oscillator strengths to highly excited and continuum states is bounded, and is in fact small, one can terminate the series and estimate the error. Preliminary estimates of $\xi_0(r)$ for argon have been completed using the Hartree-Fock-Slater potential of Herman and Skillman⁷ and terminating the series with a $6d$ state. The calculated wavelength associated with the collective frequency ω_c is $\lambda_c \approx 20 \text{ \AA}$.

We should mention that in a Thomas-Fermi model of the atom, $\delta n_0(\vec{r}, \omega)$ is proportional to $n_0(\vec{r})$, leading to a collective wavelength $\lambda_c \approx 5 \text{ \AA}$.

Estimates of the level width of the collective resonance are in progress.

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†Permanent address: Physics Department, New York University, Bronx, New York.

‡John F. Kennedy Memorial Foundation Fellow.

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⁶Since the most important contributions to the collective oscillations are assumed to come from the coupling of states just above and below the Fermi surface, the fixed effective potential should be chosen to give correctly the low-lying excited spectrum. For atoms with large Z , the ground-state Hartree-Fock Hamiltonian is useful provided it describes these states reasonably well. If this is not the case, the ground-state Hamiltonian should be modified by the addition of a fixed core potential which meets these requirements. If the effective Hamiltonian is chosen suitably, it would describe the low-lying spectrum properly, and at the same time its eigenstates would serve as a complete orthonormal basis. This is the procedure adopted in this paper.

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ALKALI IMPURITY RESISTIVITIES IN LIQUID SODIUM

J. M. Dickey

Department of Physics, University of Ghana, Legon, Accra, Ghana

Axel Meyer

Solid State Division, Oak Ridge National Laboratory,* Oak Ridge, Tennessee

and

W. H. Young†

Department of Physics, University of Sheffield, Sheffield, England

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In the process of compilation¹ of pseudoatom² phase shifts, it has been possible to test the Faber-Ziman³ theory of the resistivity of binary liquid-metal alloys, at least for dilute quantities of the various alkalis in Na at its melting point.

Comprehensive tables of phase shifts will be published in due course,⁴ the relevant data for present purposes being shown in Table I. We give not only the results evaluated at the Fermi level for Na but also, for comparison purposes, those appropriate to each pure liq-

uid at its melting point. The latter provide us with a check on our method in that they lead to cross sections in essential agreement with other calculations.⁵ The computational procedure was essentially that of Ref. 1, except that it was found convenient to reduce the Austin⁶ pseudopotential to semilocal form using an approximation discussed by Cohen and Heine.⁷ The core wave functions used were those of Herman and Skillman.⁸

The Faber-Ziman theory in a free-electron approximation which appears to be satisfactory,⁹

Table I. Pseudoatom phase shifts.

Metal	k_F	η_0	η_1	η_2	η_3
Na	0.474	0.583	0.284	0.026	0.001
Li	0.578	0.242	0.417	0.015	0.001
Li	0.474	0.449	0.357	0.010	0.003
K	0.382	0.535	0.212	0.078	0.001
K	0.474	0.254	0.143	0.174	0.002
Rb	0.357	0.574	0.191	0.083	0.002
Rb	0.474	0.221	0.087	0.213	0.004

when generalized for complex scattering amplitudes, gives

$$\Delta\rho = (9\pi^3\hbar/1600e^2k_F) \int_0^2 \{ |f_1' - f_0|^2 + [f_0 f_1'^* + f_0^* f_1' - 2|f_0|^2] \alpha(k_F \xi) \} \xi^3 d\xi, \quad (1)$$

for the resistivity per atomic percent of impurity 1, added to a pure liquid metal 0. Here, α is the pure-solvent structure factor, available experimentally¹⁰ for Na. The differential cross section (normalized as indicated for convenience) appropriate to the solvent is

$$f_0 = (2i/3\pi) \sum (2l+1) [\exp(2i\eta_l^0) - 1] P_l(1 - \frac{1}{2}\xi^2). \quad (2)$$

A similar expression holds for f_1 , where the phase shifts η_l^1 are evaluated for the impurity at the Fermi level of the solvent. The function $f_1' = f_1 - \delta f(k_F \xi) f_0$ is the modified solute differential cross section due to dilatation. The dilatation factor is denoted by δ , while the associated function, f , is defined by Faber and Ziman's Eq. (24) and is drawn in their Fig. 2

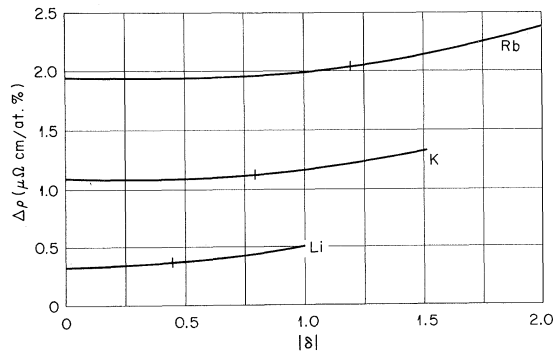


FIG. 1. Impurity resistivity of Li, K, and Rb in liquid Na for varying dilatation δ . For Li, δ is negative while for the other alkalis it is positive. The markers indicate the neighborhood of the expected physical values.

Table II. Alkali impurity resistivities, $\Delta\rho$ ($\mu\Omega$ cm) per atomic percent, in liquid Na at its melting point.

Impurity	Experiment	Toombs	Faber-Ziman
Li	0.28	0.4	0.37
K	1.02	0.7	1.12
Rb	2.55	1.5	2.05

using the Gingrich-Heaton data for the case of Na.

While δ is not known with precision for any of the systems under study, it turns out that $\Delta\rho$ is insensitive to the numerical choice of this parameter, as is clear from Fig. 1. Thus, one may take the δ 's quoted by Freedman and Robertson¹¹ and obtain, with some confidence, the values quoted in Table II. It will be noted that the present results are in somewhat better agreement with experiment¹¹ than those found by Toombs¹² using his collective approach.

The above work points to the essential validity of the Faber-Ziman theory, though it should be emphasized that because of the insensitivity of our results to δ , the particular mechanism for including dilatation has not been tested. For this purpose, a solvent with an f_0 exhibiting large backscattering would be desirable.

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†The work reported here was done while this author was in the Department of Physics, University of Ghana, Legon, Accra, Ghana.

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FARADAY ROTATION IN KTaO_3

W. S. Baer

Bell Telephone Laboratories, Murray Hill, New Jersey

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The band-structure parameters of transition metal oxides with d -like conduction bands are currently of considerable interest. The relatively high electron mobility in KTaO_3 ,¹ a cubic semiconductor, has made possible the observation of microwave resonances² and an approximate determination of the low-frequency electron effective mass. We have measured the high-frequency electron effective mass in KTaO_3 from the free-carrier contribution to the Faraday rotation. In addition, the sign of the interband Faraday rotation in both conducting and insulating KTaO_3 , as well as in several other transition metal oxides, is found to be negative (a positive rotation is defined to be in the same direction as the current in the coils producing the magnetic field).

The single-crystal KTaO_3 samples used in these experiments were grown by a modified Kyropolis method.¹ The conducting crystals with electron concentrations of about $10^{18}/\text{cm}^3$ were cut and polished to thicknesses less than 1 mm to allow transmission in the infrared despite free-carrier absorption. Electron concentrations accurate to about 5% were determined by Hall measurements assuming $R_H = 1/Ne$. The carrier concentrations appeared homogeneous over the small volume ($3 \times 1 \times 1$ mm) in the optical path. Because the expected free-carrier rotations were only a few hundredths of a degree per kilogauss per millimeter of sample thickness, an ac experimental system³ was used. Plane-polarized light transmitted by the sample passed through a rotating polarizer to a PbS detector, giving an ac signal which could be compared in phase with a reference signal. Rotation of the plane of polarization produced an electronic phase shift measurable to less than 0.05° . Details of the apparatus will be described elsewhere.

The experimental results at room temperature for insulating KTaO_3 and a sample con-

taining 1.35×10^{18} electrons/ cm^3 are shown in Fig. 1. All Faraday rotations were linear with magnetic field up to 15 kG, the highest fields employed in these experiments. The difference in rotation between conducting and insulating samples is due to free electrons and, for $\omega\tau \gg 1$, can be described by the relation⁴

$$\theta_c/tB = [Ne^3/2\pi mc^4(m^*)^2]\lambda^2, \quad (1)$$

where θ_c is the free-carrier rotation, t is the sample thickness, n is the index of refraction, m^* is the effective mass, and the other sym-

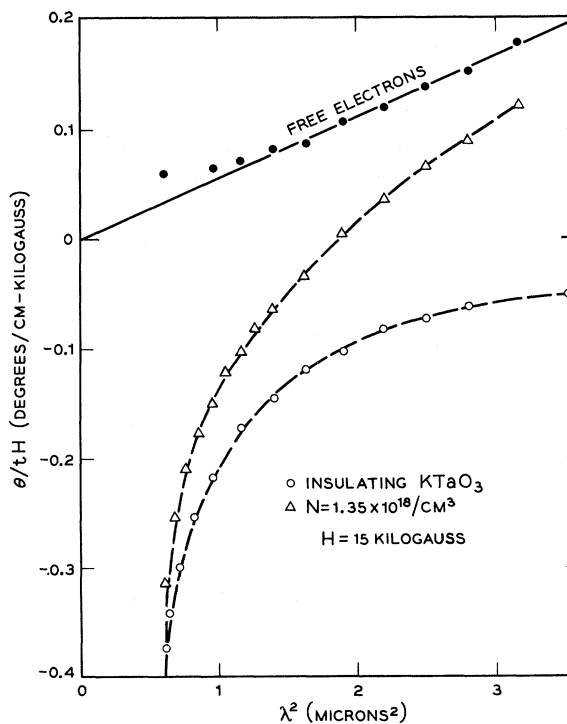


FIG. 1. Faraday rotation at 300°K in KTaO_3 . The free-electron points correspond to the difference in rotation between conducting and insulating samples.