However, the net shift of the center of gravity of the resonance field distribution is zero relative to the Knight shift of pure scandium; thus, the average induced polarization is zero, within experimental error, at the scandium sites observed in the NMR experiment. This behavior of the resonance line parameters is indicative of an oscillatory polarization of the Ruderman-Kittel-Kasuya-Yosida (RKKY)-type [2].

Although the conduction electrons in scandium are certainly not plane wave in nature we make use of a plane wave analysis [2-4] in order to estimate an effective f electron-conduction electron exchange interaction. This simple RKKY treatment neglects the details of the s-wave and d-wave scattering in scandium. Following Gossard et al.[4], simplifying approximations are made to find the sum of the simple dipole contribution and exchange contribution to $\Delta H_{\frac{1}{2}}$ from the local moment complex.

$$\Delta H_{\frac{1}{2}} = cp^2 \frac{H}{T}\left[4.4 \times 10^{-2} + 2.6 \times 10^2 K_{Sc} |J(\mathrm{eV})| \right]. \quad (2)$$

Here K_{Sc} is the Knight shift in scandium and J is the effective exchange coupling constant. From the data in table 1, a value of $|J| \approx 0.06$ eV for $K_{Sc} = 0.26\%$ is obtained.

Several conclusions can be drawn from the results discussed. The effective and saturation moments per gadolinium ion at low concentrations of gadolinium in scandium are large compared with the free ion values of Gd^{3+}. This is clear evidence of a polarization of the scandium matrix by the gadolinium. The almost constant value of the effective moment above 0.1 at.% gadolinium, which is larger than the free gadolinium paramagnetic moment of 7.94 μ_B, might indicate a clustering of the gadolinium atoms. The absence of net polarization in Sc-Gd alloys beyond the nearest scandium neighbors and the presence of an induced polarization, which apparently changes in sign and magnitude at varying distances from the localized gadolinium moment, indicates that an interaction of the RKKY-type best describes our results. The NMR results give no information, however, about the polarization of the near-neighbor shells surrounding each impurity that is primarily responsible for the large moments.

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ON THE EQUILIBRIUM CHARGE DISTRIBUTION IN HEAVY ELEMENT ION BEAMS

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Unified approximate semi-empirical formulae for the mean charge, $\bar{i}$, and width, d, of the equilibrium charge distribution in fast ion beams after their passing through solids have been obtained for all particles with atomic number $Z \gtrsim 20$.

Recently the problem of the equilibrium charge distribution in a fast ion beam after its passing through matter has become quite urgent due to the development of special accelerators for heavy element ions. This distribution may be approximately calculated by the semi-empirical method [1]

which is a further evolving of the Bohr generalized criterion for the conditions of the loss and retention of electrons by atomic particles passing through matter.

According to [1], when the statistical model of atomic particles is used, the ion velocity, v, at which the mean degree of the particle ionization, $\bar{i}/Z$, reaches the given value, should be proportional to Z^{α}. The latest experimental results for ions of Br, I, Ta and U [2-4] show that for ions with atomic number $Z \gtrsim 20$ which pass through solids the exponent, α, is practically independent of $\bar{i}/Z$. Therefore, the values of $\bar{i}/Z$ may be presented in the form of a unified function of v/Z^{α} for all Z. It possible to express this function as the following formula

$$\bar{i}/Z = [1 + (v/Z^{\alpha}v')^{-\frac{1}{k}}]^{-k} \qquad (1)$$

where $\alpha = 0.45$, $k = 0.6$, $v' = 3.6 \times 10^8$ cm/sec.

With $v \lesssim 0.3 \cdot Z^{\alpha}v'$ when $\bar{i}/Z \lesssim 0.3$, the formula (1) results in the expected [5,6] proportionality between $\bar{i}$ and v while with $v > 2Z^{\alpha}v'$ it results in the values of i approaching Z. The expressions of the type $\bar{i}/Z = A + B \exp(-v/Z^{\alpha}v')$ [2-4], at single values of A, B, α and v' for all ions, result in a somewhat worse agreement with experiment and, besides, at $A \neq B$, they do not give expected proportionality between $\bar{i}$ and v when v is small.

According to [1] the width, d, of the equilibrium charge distribution should be proportional to $(\mathrm{d}\bar{i}/\mathrm{d}\ln v)^{\frac{1}{2}}$. Therefore, the expression for d to correspond to eq. (1) will be

$$d = d_0 \{\bar{i}[1 - (\bar{i}/Z)^{\frac{1}{k}}]\}^{\frac{1}{2}} . \qquad (2)$$

According to experiments $d_0 = 0.5$ (fig. 1).

The shell structure of ions brings about natural deviations of the experimental values of i and d from the value given by formulae (1) and (2). For ions with $Z \gtrsim 20$, deviations of $\bar{i}$ do not exceed 5% and deviations of d are $\sim$ 20% (fig. 1). The minimum values of d and $\mathrm{d}\bar{i}/\mathrm{d}\ln v$ correspond to the ions whose electrons from completely filled shells. In this connection the diminished value of d for the U ions, their energy being $E \approx 100$ MeV, can be naturally explained by the filling of the N shell. At other energies of U ions one should expect the value of d to be in a better agreement with those obtained from (2).

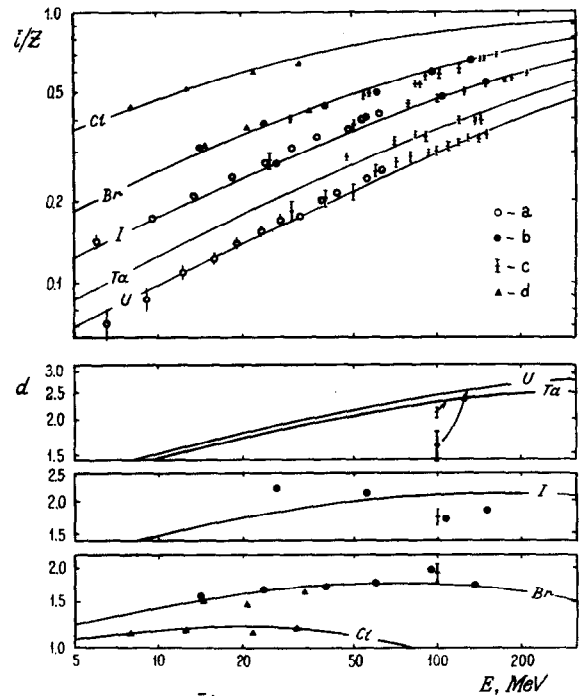

Fig. 1. Values of $\bar{i}/Z$ and d versus energy E for ions of Cl, Br, I, Ta and U. a,b,c,d - experimental results from refs. 2,3,4 and 7, respectively. The lines give the values of $\bar{i}/Z$ and d calculated by the formulae (1) and (2).

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