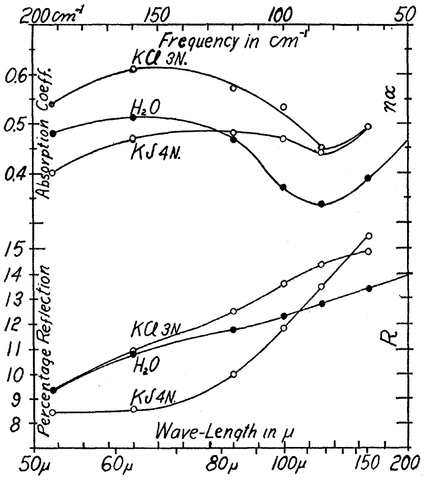

FIG. 1.

The characteristic wave-lengths for K, Cl, and I ions given above were calculated under the assumption that the ions were free to move with respect to the water molecules surrounding them. A comparison of the curves for KCl with those for KI seems to justify this assumption, at least for the amplitudes produced by the radiation employed. The rigid attachment of water molecules to the ions might be expected to change the ratio of M to r in Eq. (2) so that the characteristic wave-lengths would not be consistent with the data shown in the figure. A better criterion for deciding if there are water molecules attached to the ions is offered by considering the value of the absolute absorption as obtained from inserting the above equations in Maxwell's equations. A calculation shows that the ions in KCl and KI solutions are free to move with respect to the surrounding water molecules. However, in electrolytes of LiCl and $MgSO_4$ our data indicate that water molecules move with the ions. It seems noteworthy that the viscosities of KCl and KI solutions are practically the same as that of pure water while LiCl and $MgSO_4$ solutions are considerably more viscous. Also electrolytes of Li and Mg ions have abnormally small electrical conductivities.

We conclude that the dispersion of electrolytes in the extreme infrared can be pictured classically by considering the ions to follow in translation the alternations of electromagnetic waves. The motion of the ions decreases in amplitude as the frequency of the radiation increases because of their inertia and the friction against the neighboring molecules. In electrolytes of KCl and KI, the ions seem to move with respect to the water molecules except for friction.

I am indebted to Professor P. Debye, for having kindly derived the appropriate equations, and to Professor J. Errera, the University of Brussels, the Fonds National Belge de la Recherche Scientifique, and C. R. B. Educational Foundation for their generous help.

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November 30, 1935.

Exchange Forces and the Structure of the Nucleus

The forces between elementary particles in the nucleus have been supposed to be of three types, which may be denoted as Wigner, Heisenberg or Majorana. The Wigner forces are of the ordinary kind, not involving exchange; the Heisenberg forces involve an exchange of both spin and space coordinates; and the Majorana forces involve an exchange of space coordinates alone.

According to Wigner,[1] one might account for the large neutron-proton scattering cross section by assuming the interaction of neutron and proton to depend on the relative orientation of the spins. Van Vleck[2] has suggested that, since the Heisenberg forces depend on spin orientation and the Majorana forces do not, the interaction could be described by a linear combination of Heisenberg and Majorana forces. Feenberg and Knipp[3] have shown that such an interaction can give an arbitrarily large scattering cross section, provided that the proper linear combination is chosen. It does not seem to the present writer, however, that the treatment is complete, since there is still another type of exchange conceivable, and this is obtained by making a Heisenberg exchange and then a Majorana exchange. This amounts to interchanging the spin coordinates and not the space coordinates. (We could perhaps compare the present situation to the interaction of an excited atom with a normal atom. Two types of processes occur here, and have been denoted by "austausch" and "resonance," respectively. The effect due to combination of the two is of the same order of magnitude as that of each alone.) The most general exchange operator would then include this spin exchange term as well as the others.

In this connection, a rather convenient formalism for treating the nucleus as a many-body problem suggests itself. Following Heisenberg,[4] one can suppose all the particles in the nucleus to be identical, but just in different states. The interaction operator will then be, in this scheme, the same for all pairs of particles. If now, we take the resulting wave function for the total system to be a determinant wave function, an analysis similar to that of Slater[5] can be carried through. If $V(12)$ is the above interaction operator, and if m and n denote space-spin states, while ν, π denote proton, neutron, respectively, then we obtain integrals of the type $\int u^*(m\nu/1)u^*(n\pi/2)V(12)u(m\nu/2)u(n\pi/1)d\tau_1 d\tau_2$. Here, particle 1 makes a transition from state m, ν to state n, π, while particle 2 does the opposite. That is, this integral represents a matrix element of the interaction between neutron and proton. It may be possible, from the observed masses of the light elements, to determine these matrix elements. A study of this is now being made, and will be reported later.

I wish to thank Dr. Feenberg for allowing me to see his manuscript before publication.

JAMES H. BARTLETT, JR.

University of Illinois,
December 14, 1935.

1 Feenberg and Knipp, Phys. Rev. **48**, 906 (1935); footnote 13.
2 Feenberg and Knipp, Phys. Rev. **48**, 906 (1935).
3 Reference 1, footnote 14.
4 W. Heisenberg, Zeits. f. Physik **77**, 1 (1932).
5 J. C. Slater, Phys. Rev. **34**, 1304 (1929).