Rapid-Passage Effects in Electron Spin Resonance

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UNDER this title, a work was recently published in this journal by Portis.[1] In this paper, relaxation effects observed in electron spin resonance from F centers in alkali halides[2] and from donor states in silicon,[3] are interpreted in terms of the rapid-passage theory of Bloch.[4] The purpose of this letter is to point out that another rapid-passage effect in electron spin resonance was previously observed and interpreted in our laboratory.[5] The phenomenon, well known in nuclear magnetic resonance as "wiggles",[6] obtained in rapid-passage conditions, was produced in ammonia solutions of metallic sodium.

As reported in our paper, these conditions were obtained at the Larmor frequency of 23 Mc/sec (static field of approximately 8.2 gauss) and a sinusoidal field sweep of frequency 2 kc/sec and amplitude 1.1 gauss. The wiggles observed are illustrated in the figure of reference 5.

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Guanidine Vanadium Sulfate Hexahydrate: A New Ferroelectric Material

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IN two previous papers[1,2] we reported a new class of ferroelectric crystals and discussed some of their properties. This class of crystal is represented by guanidine aluminum sulfate hexahydrate (G.A.S.H.) with the formula $C(NH_2)_3Al(SO_4)_2\cdot 6H_2O$. We also reported the ferroelectric nature of the isomorphous crystals in which the Al ion is replaced by Ga or Cr, of those in which the S ion is replaced by Se, and of those in which the water is replaced by heavy water. They showed essentially the same properties as G.A.S.H.

We have succeeded in obtaining large crystals of an isomorphous vanadium compound, $C(NH_2)_3V(SO_4)_2\cdot 6H_2O$ (G.V.S.H.), where trivalent vanadium replaces the aluminum in the parent compound. The material was made by dissolving equimolar proportions of vanadium trioxide and guanidine carbonate in water with a small excess of the requisite amount of H_2SO_4. The crystals produced are purple-red by transmitted light. The basal cleavage in G.V.S.H. is not quite as distinct as that of G.A.S.H. We have not been able to make the isomorphous guanidine vanadium selenate hexahydrate because of the reduction of the selenic acid to selenous by the trivalent vanadium.

The physical properties of G.V.S.H. are very similar to those of G.A.S.H. and the other isomorphs. The spontaneous polarization P_s at room temperature is 0.38 microcoulomb/cm^2. The dielectric constant ϵ_c along the ferroelectric axis is somewhat higher. The shapes of the 60-cycle hysteresis loops, however, are definitely better in the vanadium compound. The loops are seen to be very much more rectangular and show less bias. This is especially true after 60-cycle aging. This treatment seems to bring about a permanent improvement in the vanadium compound, whereas in the parent compound and the other isomorphs, this improvement does not seem to be as pronounced. We believe that the rectangularity of the hysteresis loop and smaller bias make the vanadium compound unique among the presently known isomorphs of G.A.S.H. These differences might be due to the unusual valence state of vanadium. The 60-cycle coercive field E_c is larger than in G.A.S.H., i.e., about 6000 volts/cm at room temperature. The temperature dependence of P_s and E_c is characteristic of the parent compound.

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Proton Charge Density*

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THE recent experiments on electron-proton scattering[1] carried out at Stanford have begun to give some insight into the structure of the charge distribution in a physical proton. This distribution of charge is, in the outer regions, probably produced by the cloud of virtual π mesons surrounding the proton. Near the core, however, heavier mesons will undoubtedly also contribute. Since a large number of phenomena involving π mesons can be described reasonably well in terms of the theory of Chew and Low,[2] it is of interest to find the meson charge density predicted by this theory.

For a static nucleon the charge density of the meson cloud may be expressed as

$$\rho(x)=(\psi_0|\rho_\pi(x)|\psi_0),$$

where ψ_0 represents the physical nucleon state, and

$\rho_\pi(x)$ is the meson field charge density operator, defined by

$$\rho_\pi(x) = -ie[\pi(x)\varphi(x) - \pi^*(x)\varphi^*(x)],$$

where φ is the charged meson field and π is the momentum of the field. This can be written in terms of meson creation and destruction operators by using the expansions

$$\varphi = \sum_k \frac{1}{(2\omega_k)^{\frac{1}{2}}}(a_k^\dagger e^{-i\mathbf{k}\cdot\mathbf{x}} + b_k e^{i\mathbf{k}\cdot\mathbf{x}}),$$

$$\pi = i\sum_k \left(\frac{\omega_k}{2}\right)^{\frac{1}{2}}(a_k e^{i\mathbf{k}\cdot\mathbf{x}} - b_k^\dagger e^{-i\mathbf{k}\cdot\mathbf{x}}),$$

where a_k and b_k are associated with positive and negative mesons, respectively.

One is thus interested in calculating quantities like $(\psi_0|a_k^\dagger a_{k'}|\psi_0)$. This may be done using the identity[2]

$$a_k\psi_0 = -\frac{1}{H+\omega_k}V_k^\dagger\psi_0,$$

where H is the entire Hamiltonian, and the meson nucleon interaction H' is given by

$$H' = \sum_k (a_k V_k + a_k^\dagger V_k^\dagger).$$

If one then makes the "one-meson approximation"[2] on the resulting expression for $\rho(x)$, one can write $\rho(x)$ as the contribution from renormalized perturbation theory,[3] plus terms representing the contribution from one-meson intermediate states; namely,

$$-\frac{e}{2}\sum_{kk'}\left[\left(\frac{\omega}{\omega'}\right)^{\frac{1}{2}} - \left(\frac{\omega'}{\omega}\right)^{\frac{1}{2}}\right]e^{i(\mathbf{k}-\mathbf{k}')\cdot\mathbf{x}}$$
$$\times\left\{\frac{1}{\omega+\omega'}[T_{-k',-}(k,+) - T_{-k',-}^*(-k,-)]\right.$$
$$+\sum_s \frac{T_{-k,-}^*(s)T_{-k',-}(s)}{(\omega_s-\omega-i\epsilon)(\omega_s+\omega')}$$
$$\left. - \frac{T_{-k',-}^*(s)T_{-k,-}(s)}{(\omega_s+\omega')(\omega_s-\omega-i\epsilon)}\right\}.$$

Here $T_q(p) = (\psi_p^{(-)}, V_q^\dagger\psi_0)$ represents the scattering amplitude to scatter a meson from a state q to a state p. This can be related to the experimental meson-nucleon scattering phase shifts through

$$T_q(p) = \frac{q}{p}\left(\frac{\omega_p}{\omega_q}\right)^{\frac{1}{2}} T(p),$$

where $T(p)$ is the experimental (on the energy shell) scattering amplitude for a meson of energy ω_p.

In carrying out the integrals, it has been assumed that all phase shifts except δ_{33} are zero. δ_{33} has been taken

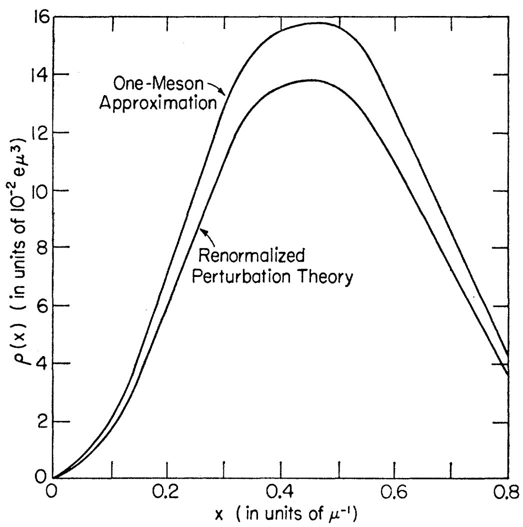

FIG. 1. Proton charge density $\rho(x)$.

from the formula

$$\tan\delta_{33} = \frac{\Gamma/2E_r}{1-E/E_r},$$

where $\Gamma/2E_r = 0.30\eta^3/(1+\eta^2)$, $E_r = 162$ Mev, which fits the experimental data quite well.[4] The integrals all depend quite sensitively on the cutoff, which has been taken at 6μ.

The resulting $\rho(x)$ is shown in Fig. 1. The deviations from the perturbation result of Salzman[3] do not amount to more than 10 or 15% for this cutoff. The only approximation involved here is the one-meson approximation. This is believed to be reasonably good. In any case, it is unlikely that contributions from two-meson and higher intermediate states will be larger than the errors introduced by uncertainties in the cutoff, on which the integrals depend fairly sensitively.

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Interpretation of K^+-Scattering in Nuclear Emulsions*

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EXPERIMENTS[1] on the tracking of K^+-particles through nuclear emulsions have shown the K^+-nucleon scattering interaction to be small and K^+-ab-