

The line width in most of these experiments was very small and was in practice determined by the inhomogeneity of the magnetic field over the specimen. One exception to this statement was glycerin in its highly viscous supercooled condition, which reached a width rather more than 1 gauss at the lowest temperature of measurement. Making, as before, the simplifying assumption that the correlation times τ_{oj} are all equal, we find from (5.26) in the region of short τ_o , that

$$\delta\nu = C_3\tau_o \quad (5.35)$$

where
$$C_3 = \frac{3\xi}{4\pi^2} \gamma^4 \hbar^2 I(I+1) \sum_j |Y_{0j}|^2. \quad (5.36)$$

The condition of shortness is less stringent than for the spin-lattice relaxation time approximations, because we merely require $2\pi\xi\delta\nu\tau_o \ll 1$, and for the glycerin measurements this should be satisfied at all except perhaps the very lowest temperatures. The experimental values of line width $\delta H (= 2\pi\delta\nu/\gamma)$ are shown in fig. 32 plotted against η/T , to which τ_o should be proportional, and in fact the two quantities are found to be roughly proportional.

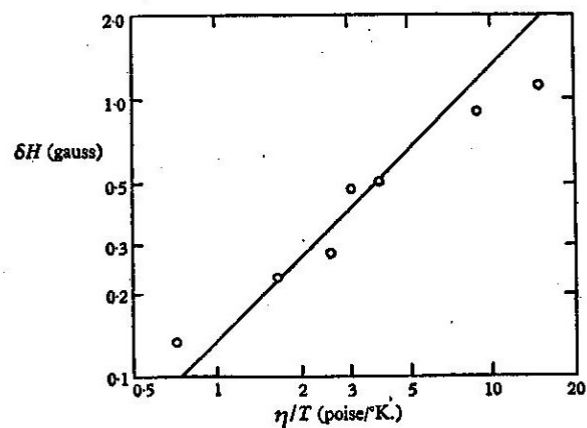


Fig. 32. Resonance line width δH for protons in glycerin plotted against the ratio of viscosity to temperature (Bloembergen, Purcell and Pound, 1948).

The effect of dissolved paramagnetic ions on the proton resonance in water has also been studied by Bloembergen, Purcell and Pound; the marked reduction in T_1 which results had already been demonstrated by Bloch, Hansen and Packard (1946 b). The mag-

netic moment of a paramagnetic ion is of the order of one Bohr magneton, and is thus some 10^3 times larger than a nuclear magnetic moment. The fluctuating local magnetic field will therefore be correspondingly larger and the relaxation time T_1 shorter. The relaxation produced by the ions is intermolecular, and we therefore seek an appropriate modification of expression (5.19), which referred to intermolecular relaxation by protons. In Appendix 3, it is pointed out that the modification is achieved by substituting μ_{ion}^2 , where μ_{ion} is the effective magnetic moment of the ion, for $\gamma^2 \hbar^2 I(I+1)$, which for the proton is $\frac{3}{4} \gamma^2 \hbar^2$. The modified form of (5.19) is therefore

$$\frac{1}{T_1} = 12\pi^2 \gamma^2 \eta N_{ion} \mu_{ion}^2 / 5kT, \quad (5.37)$$

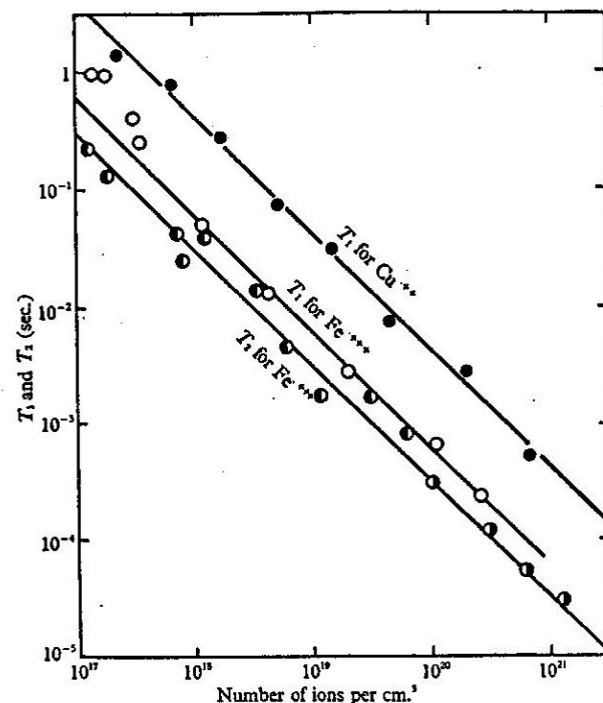


Fig. 33. Values of T_1 and T_2 for solutions of paramagnetic salts. ● T_1 for Cu^{++} ions, ○ T_1 for Fe^{+++} ions, ● T_2 for Fe^{+++} ions, all from Bloembergen, Purcell and Pound (1948). ● T_2 for Fe^{+++} ions from Gabillard (1952 b). Values of T_1 and T_2 for ferric ions, in excellent agreement with those shown, are reported by Chiarotti and Giulotto (1953) and Hahn (1950 b) respectively.