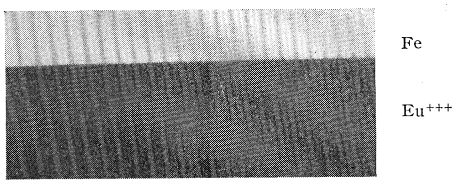

FIG. 1. $Eu_2(SO_4)_3 8H_2O$ crystal room temperatures 5780A region.

solved in B_2O_3 glass. A number of the lines in both solids were extremely sharp even at room temperatures. (See Figs. 1 and 2.) Eu_2O_3 does not seem to be very soluble in B_2O_3 as the clear beads of B_2O_3 did not show sufficient absorption to register on the plate. Opalescent beads containing suspended Eu_2O_3 were therefore used. The absorption multiplets are well suited for measuring Doppler shifts of other lines as the multiplets are simple and well placed, e.g. 4600A, 5200A and 5700A. The lines in solution are also fairly sharp (much better than Nd) and could be used instead of Nd. However, it should be possible to prepare a clear glass similar to Didinium glass in which the lines would still remain sharp and which would be much more convenient for astronomers.

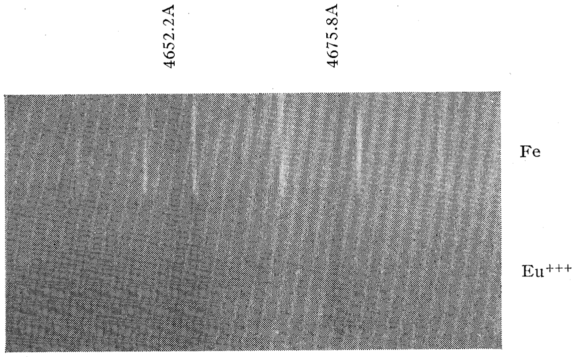

FIG. 2. Eu_2O_3 in B_2O_3 glass, room temperatures.

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[1] H. N. McCoy, J. Am. Chem. Soc. 58, 1577 (1936).

The Proton's Magnetic Moment

A disagreement seems to exist between the values for the proton's magnetic moment, obtained by Stern and by Rabi and their co-workers. The former was the first to measure this fundamental quantity and to discover that the proton did not possess the expected magnetic moment, one nuclear magneton, but a moment 2.5 times this value.[1] An error of approximately 10 percent could be allowed in these earliest measurements. Rabi, using an entirely different method, made a new determination of μ_π and obtained the value 2.85 nm[2] with an accuracy ±0.15 nm. Stern and his colleagues, have continued their experiments, refining the method and checking carefully all things involved in the calculation of μ_π from the directly measured quantities. Their result, personally communicated,[3] is that μ_π equals 2.46 ± 0.08 nm. Thus, it seems that two different methods lead to different values for the same quantity. This, of course, makes it important that both experiments be scrutinized carefully to see that no systematic error is involved in either or whether some factor has been overlooked. At present, it seems improbable that any correction or revision can bring the two experiments into agreement. Let us assume that this is the situation.

We must then look for a fundamental difference in the two experiments. Stern's experiment measures the deflection of hydrogen molecules in an inhomogeneous macroscopic magnetic field; and it is assumed in calculating μ_π, first, that the protons possess a magnetic moment, and secondly, that the energy of such a moment in a magnetic field is that given by classical electrodynamics. Rabi's experiment, on the other hand, deals with hydrogen atoms, and measures essentially the strength of external magnetic field necessary to produce a definite degree of uncoupling of the *spins* of the electron and proton, assuming that the spins are coupled only through the interaction of their associated magnetic dipoles. If, in reality, an extra spin-spin interaction between electron and proton existed, the exterternal magnetic field in Rabi's experiment would have to be strong enough to break down the coupling effect of this interaction plus the magnetic dipole interaction. Determination of nuclear magnetic moments from hyperfine structure involves the same assumption as Rabi's experiment and, in case the hypothesis of an extra electron-proton spin-spin interaction should prove tenable, all magnetic moments determined in this way would be necessarily in error. The accuracy with which the h.f.s. interval rule is obeyed practically requires that the extra interaction be represented in the form of a scalar product of the electron and proton spins multiplied by a function of the electron-proton separation

$$U = -(\boldsymbol{\sigma}_\epsilon \cdot \boldsymbol{\sigma}_\pi) V(r_{\epsilon\pi}).$$

In exactly the same way that we introduce the characteristic electron size ϵ^2/mc^2 from a consideration of the electrostatic self-energy, we may establish another such quantity, $r_\mu = (\mu_\epsilon^2/mc^2)^{\frac{1}{3}}$ from a consideration of the magnetic self-energy ($r_\mu \sim 5 \times 10^{-12}$ cm). If the quantity $V(r_{\epsilon\pi})$ were assumed to have an appreciable value only within distances of the order r_μ, then it would have to have an average value of the order of only 10^3 electron volts to explain the discrepancy between Stern's and Rabi's results.

Breit[4] has shown that a spin dependent interaction of this type satisfies all relativistic requirements which we may reasonably impose. Although he was mainly interested in the possibility of learning something about specifically nuclear interactions between heavy particles, his treatment applies to all elementary particles and hence allows the possibility of such an interaction between electrons and protons.

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Pittsburgh, Pennsylvania,
June 28, 1937.

[1] Frisch and Stern, Zeits. f. Physik 85, 4 (1933); Estermann and Stern, Zeits. f. Physik 85, 17 (1933).

[2] Kellogg, Rabi and Zacharias, Phys. Rev. 50, 472 (1936).

[3] Estermann, Simpson and Stern, to be published soon.

[4] Breit, Phys. Rev. 51, 248 (1937).