scalar units in desired combinations. The H_1 intensity of the square wave is constant throughout a T_1 measurement, giving $n_i=k(H_1)n_0$ where $k(H_1)$ is a proportionality factor which is constant for H_1 constant. In Fig. 1, n corresponds to the measured height of the inverted signal occurring at the time t chosen; n_0 corresponds to the measured height of the positive signal at $t=0$. For distilled water (not in vacuum) the data illustrated in Fig. 2 give $T_1=2.33\pm0.07$ sec. as compared with 2.3 ± 0.5 sec. measured by Purcell *et al.*[1] For this particular case, five measurements were made per point. The method permits even higher accuracy if more measurements per point are taken. The single signals seen here are much larger than ordinary periodic resonance signals, and signal to noice ratio is high. Shorter values of T_1 can also be measured by subjecting the sample to higher frequency H_0 field modulation.

* This work was supported in part by ONR contract N6-ori-71.
[1] Bloembergen, Pound, and Purcell, Phys. Rev. **71**, 466 (1947).
[2] This method appears to be similar to one reported by H. C. Torrey, Phys. Rev. **75**, 1326 (1949).
** This effect will be discussed in a paper to be published on the nutation of the nuclear magnetic moment.

An Error in a Paper by Landau on Coulomb Interactions in a Plasma*

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LANDAU[1] attempts to show that the Coulomb interactions of electrons and ions in a plasma can be represented as the divergence of a flow vector in momentum space. To obtain this result he expands the probability w of scattering through a small angle in powers of that angle without properly taking into account the singularity of w at zero deflection. Fortunately this expansion is avoided by reversing the integration by parts. Landau's Eq. (1) is

$$\int[n(p)n'(p')-n(p+\Delta)n'(p'-\Delta)]w(p-p',\Delta)d\tau' d\tau_\Delta. \quad (1)$$

The distributions n, n' are continuous and can be expanded in powers of Δ

$$n(p+\Delta)=n(p)+\frac{\partial n}{\partial p_i}\Delta_i+\frac{1}{2}\frac{\partial^2 n}{\partial p_i\partial p_k}\Delta_i\Delta_k,$$

$$n'(p'-\Delta)=n'(p')-\frac{\partial n'}{\partial p_i'}\Delta_i+\frac{1}{2}\frac{\partial^2 n'}{\partial p_i'\partial p_k'}\Delta_i\Delta_k.$$

Substituting in (1) the zero order terms cancel and the first order terms vanish on integration, leaving

$$\int\left[\frac{\partial n}{\partial p_i}\frac{\partial n'}{\partial p_k'}-n'\frac{\partial^2 n}{\partial p_i\partial p_k}+\frac{\partial n}{\partial p_i}\frac{\partial n'}{\partial p_k'}-n\frac{\partial^2 n'}{\partial p_i'\partial p_k'}\right]w\frac{\Delta_i\Delta_k}{2}d\tau' d\tau_\Delta. \quad (2)$$

This expression is correct. The last two terms are now integrated by parts, and use made of the relation

$$\partial w/\partial p_k'=-\partial w/\partial p_k,$$

giving

$$\int\left[\left(\frac{\partial n}{\partial p_i}\frac{\partial n'}{\partial p_k'}-n'\frac{\partial^2 n}{\partial p_i\partial p_k}\right)w+\left(n'\frac{\partial n}{\partial p_i}-n\frac{\partial n'}{\partial p_i'}\right)\frac{\partial w}{\partial p_k}\right]\frac{\Delta_i\Delta_k}{2}d\tau' d\tau_\Delta. \quad (3)$$

This is Landau's result on page 156 *except for the sign before the second parenthesis.* Unfortunately this expression does not reduce to a divergence.

There is a further error in Landau's method, which I have followed in going from (2) to (3) in order to point out the error in sign. The vector $(\mathbf{p}+\mathbf{p}')/2=\mathbf{g}$ represents the motion of the center of gravity and the conservation laws require $\mathbf{p}$, $\mathbf{p}'$, $\mathbf{p}+\mathbf{\Delta}$, and $\mathbf{p}'-\mathbf{\Delta}$ to terminate on a sphere about $\mathbf{g}$. The integration by parts was done holding $\mathbf{p}$ and $\mathbf{\Delta}$ constant. This obviously restricts $\mathbf{p}'$. To be correct the integration should be at constant scattering angle, in which case the quantity $\Delta_i\Delta_k$ occurs with w in the derivative $\partial(w\Delta_i\Delta_k)\partial p_k$.

Unless the second half of (3) can be shown to be small, these errors will affect the results of Cahn[2] in two recent papers on the velocity distribution in a plasma.

* This work has been supported in part by the Signal Corps, the Air Materiel Command, and ONR.
[1] E. Landau, Physik Zeits. Sowjetunion **10**, 154 (1936).
[2] J. H. Cahn, Phys. Rev. **75**, 293, 838 (1949).

Proton Range-Energy Relation

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RECENT experiments have provided several points for the proton range-energy relation at low energies. We wish to report two more points and review the available data. The review is limited to data from cloud chambers since these experiments give mean ranges directly. The results of these determinations are shown in Fig. 1. The experimental points are numbered to correspond to paragraphs in the text. The Livingston and Bethe[1] (hereafter L & B) and the Cornell revised 1938[2] range-energy curves are included for comparison. All data are at S.T.P. (15°C, 76 cm Hg).

Point I: Twenty-eight tracks, equivalent in weight to fourteen tracks of good quality were obtained from the $H^2(\gamma,n)H^1$ reaction using Ga^{72} γ-rays in a cloud chamber filled with D_2 and D_2O vapor.* The expansion ratio was 1.36, the average temperature was 26.2°C and the total pressure was 65.1 cm before expansion. The mean range in deuterium was 0.53 ± 0.03 cm which, using the differential stopping powers of Blackett and Lees,[3] is equivalent to 0.18 ± 0.01 cm in air. Using $E_\gamma=2.250\pm0.05$ Mev[4] and a deuteron binding energy of 2.237 ± 0.005 Mev[5] E_p becomes 0.13 ± 0.03 Mev.

Point II: A similar experiment was performed using the γ-rays from ThC''. Thirty-five tracks of good quality were obtained at an expansion ratio of 1.33 at an average temperature of 21°C and

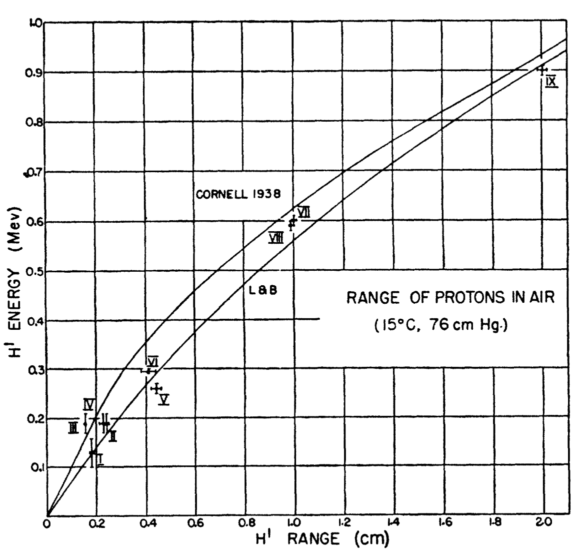

FIG. 1. Range of protons in air (15°C, 76 cm Hg).