

of the disintegration particles to an angle of  $99.5^\circ \pm 2^\circ$  to the direction of the incident 100 kev deuterons, which bombarded a  $D_3PO_4$  target. The stopping power of the gas in the chamber (1.18) was determined from the mean range (14.7 cm) of the proton group of maximum energy.

Figure 1 gives the range distribution of the protons observed, and, contrary to what one might expect, there is no indication of more than a single group. Preliminary experiments with a  $D_2O$  target frozen by liquid air gave similar results, though a higher background was present. From this experiment and that described below we conclude that  $H^3$  is excited to a level between 0.4 and 2.9 Mev in less than 2 percent of the disintegrations, if at all.

While looking for low energy protons from the deuterium reaction we observed the range of the  $H^3$  particles produced in the same reaction. An accurate determination of the range of these particles is useful in checking the range-energy relation for  $H^3$  particles, and hence the range-energy curve for short range protons.

The  $H^3$  particles were observed in a cloud chamber filled with helium and water vapor. They were allowed to pass into the cloud chamber through the slit system and an aluminum foil with a stopping power of 0.50 cm.<sup>4</sup> Fig. 2 gives the range distribution of the particles. The stopping power of the gas was found to be  $0.30 \pm 0.01$  cm for particles with a range of 3.80 cm (polonium alpha-particles).

The most probable range is  $1.28 \pm 0.10$  cm, which corresponds to a mean range of  $1.31 \pm 0.10$  cm at  $99.5^\circ$ . Since the

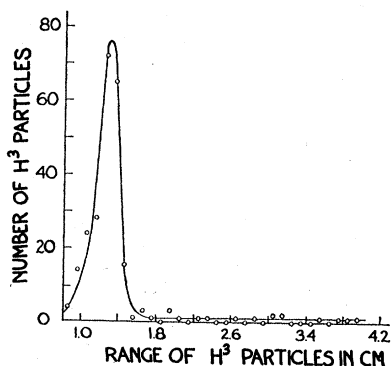


FIG. 2. Range distribution of the charged particles as observed in the helium filled chamber.

stopping power of the helium would probably be slightly higher for 1.3 cm particles than for polonium alpha-particles, this is actually a lower limit to the  $H^3$  particle range.

The energy of the  $H^3$  particles emitted at  $99.5^\circ$  was calculated from the  $Q$  value of 3.98 Mev.<sup>5</sup> The energy of the  $H^3$  particles is 0.89 Mev at this angle. The range of a  $H^3$  particle of this energy theoretically is three times the range of a proton with an energy of  $0.89/3$  Mev. If we use the new range-energy curve of Livingston and Bethe for protons, the mean range of the  $H^3$  particles should be 0.95 cm. This is beyond the limits of experimental error and we conclude that their range-energy curve for protons

in this region is in error. The experimental range of 1.31 cm is in much better agreement with the old curve of Livingston and Bethe<sup>6</sup> which predicts an  $H^3$  range of 1.38 cm.

This suggested change in the range-energy relation for protons is important since it would necessitate raising the mass of the neutron, and lowering the mass of  $He^3$  and  $C^{14}$ .

EMMETT HUDSPETH  
T. W. BONNER

The Rice Institute,  
Houston, Texas,  
June 21, 1938.

<sup>1</sup> T. W. Bonner, Phys. Rev. **52**, 685 (1937); **53**, 711 (1938).

<sup>2</sup> Baldinger, Huber, and Staub, Helv. Phys. Acta **11**, 245 (1938).

<sup>3</sup> T. W. Bonner, Phys. Rev. **52**, 685 (1937).

<sup>4</sup> The stopping power of the foil was calculated by assuming 1.41 mg/cm<sup>2</sup> = 1 cm air.

<sup>5</sup> Oliphant, Kempton, and Rutherford, Proc. Roy. Soc. **A149**, 406 (1935).

<sup>6</sup> Livingston and Bethe, Rev. Mod. Phys. **9**, 245 (1937).

### Ferromagnetic Colloid for Studying Magnetic Structures

The magnetic structure of a ferromagnetic material can be revealed by depositing a fine ferromagnetic powder from suspension onto the smooth surface of a specimen which is suitably magnetized. F. Bitter,<sup>1</sup> who first studied magnetic structures by this method, used finely ground gamma-ferric oxide suspended in ethyl acetate. Stray fields near the surface of the specimen guide such a ferromagnetic powder as it settles; the powder thereby forms a pattern recording regions where  $H^2$  is greater than in near-by regions. A similar technique for obtaining patterns has been used by most of the other investigators<sup>2</sup> who have extended the work of Bitter. McKeethan and Elmore,<sup>3</sup> however, used a true colloid (rather than a temporary suspension) of gamma-ferric oxide. They discovered that the colloid formed patterns consisting of swarms of sol particles which under favorable conditions did not settle out or coagulate but which retained their mobility within the solution. Although this latter technique possesses many advantages over the former, no great use seems to have been made of it, a fact undoubtedly due to the difficulty of securing or of preparing a suitable colloidal suspension. This situation has prompted the writer to look for a simple means of making a ferromagnetic colloid for magnetic powder investigations.

A series of experiments have led to the preparation of a very satisfactory colloidal magnetite. The new colloid forms patterns rapidly, does not coagulate once the pattern is formed, and is superior for subjective observation and for photography since its color is a very dark reddish-black (gamma-ferric oxide is a light brick-red). Several colloidal magnetites which were prepared proved unsatisfactory. One of these, protected by dextrin, had such a fine particle size that it formed patterns only in regions possessing very intense stray fields. Another one, unprotected, produced instead of the expected pattern tree-like structures which did not disperse when the applied magnetic field was removed from the specimen. To be useful for forming patterns evidently the colloid particles must not be too small, i.e., they must lie in the upper range of colloidal size. They must also be protected by another colloid to

prevent their coagulation when they congregate near the surface of the specimen. The surface itself should be protected by a thin layer of lacquer made, for instance, by dissolving a little celluloid in amylacetate.

To make the new colloid, first prepare a coarse, flaky precipitate of magnetite by Lefort's method:<sup>4</sup> dissolve 2 grams of  $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$  and 5.4 grams of  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$  (or equivalent amounts of the sulphates) in 300 cc of hot water and add with constant stirring 5 grams of NaOH dissolved in 50 cc of water. Filter to remove salt and excess sodium hydroxide. Rinse precipitate in filter several times with water and finally once with 0.01 *N* HCl. Then transfer precipitate to one liter of one-half percent soap solution and boil for a short time. The former precipitate will now have become entirely colloidal with the exception

of a very small quantity of undispersed oxide which should be removed by filtering hot. It is interesting that the success of the method depends entirely on the peptization of the precipitate with HCl before it is added to the water containing soap which serves as a protective colloid. A drop or two of the colloidal magnetite placed on the magnetized specimen will give an ample supply of sol particles for forming a pattern.

W. C. ELMORE

Massachusetts Institute of Technology,  
Cambridge, Massachusetts,  
July 19, 1938.

<sup>1</sup> F. Bitter, *Phys. Rev.* **38**, 1903 (1931); **41**, 507 (1932).

<sup>2</sup> F. Bitter, *Introduction to Ferromagnetism* (McGraw-Hill Book Co., 1937), p. 59.

<sup>3</sup> L. W. McKeehan and W. C. Elmore, *Phys. Rev.* **46**, 226 (1934).

<sup>4</sup> See, for instance, L. A. Welo and O. Baudisch, *Phil. Mag.* **3**, 396 (1927).