# DISCUSSION

## THE MAGNETIC ION

THE general belief that our universe consists of matter (of the chemical elements) and of electricity is founded on the observations of M. Faraday,[1] who stated that there are material bodies moving in homogeneous electric fields in the direction of the electric lines of force or against them. These bodies, whose direction of motion is reversed with the field, were called "ions" by M. Faraday. Thus an electric ion is a body or particle which carries an excess of positive or negative electric charge.

It is well known that electric ions can be produced by different means such as friction, chemical processes, light and other ionizing agents (for example, radium), etc., and that the charges on these ions can also be changed by the same means.

Magnetism played a secondary role for the last centuries, since during all that time the opinion prevailed that there are no true magnetic charges. No matter how small a body or particle was, it always was supposed to have the same amount of north as of south magnetism. This opinion was based on observations according to which a body directed itself in the direction of the homogeneous magnetic lines of force as a compass needle does in the geomagnetic field, but did not move from its place.[2] Thus a force acting on the north magnetic pole was supposed to be equal to that on the south magnetic one and therefore only such oppositely charged magnetic dipoles were believed to exist. According to J. M. Ampere, each of the dipoles or magnets could be substituted by circular electric currents. Therefore, particles or bodies with an excess of magnetic charge should not exist.

However, more sensitive experiments of F. Ehrenhaft,[3] carried out on very small test bodies with greater mobilities in strong homogeneous magnetic fields, showed that particles of various elements such as Fe, Ni, Sb, etc., move in or against the direction of the lines of force if they were irradiated by light (magneto-photophoresis). From a swarm of such particles, which are suspended in gas, some move towards the north magnetrode some towards the south magnetrode, while others remain at rest. The moving bodies reverse the direction of motion with the field and stop instantly if the magnetic field is shut off. Their velocities increase or decrease if the intensity of the illuminating beam increases or decreases. Furthermore, the test bodies pass very closely to each other in opposite directions.

In the spirit of M. Faraday and J. C. Maxwell one must therefore conclude[4] that there is an excess of magnetic charge on these test bodies which show a distinct motion under the influence of homogeneous magnetic fields. These particles, therefore must be considered as magnetic ions. Furthermore, there are, as F. Ehrenhaft has shown,[5] magnetic currents since the flow of these magnetic ions itself represents a magnetic current.

Just as there are electric ions created by light, light can also produce magnetic ions, *i.e.*, bodies, which move in homogeneous magnetic fields.

In the following recent experiments will be described which demonstrate that the magnetic ions, which are produced by light, are only a special case of a much more general phenomenon. The experiments were executed in an Ehrenhaft condenser[6] whose plates (8 mm in diameter and about 2 mm apart), were the basis of iron cylinders which created a vertical magnetic field whose direction could be reversed at will. A reversible electric field could likewise be applied in the same direction if needed. Both fields were strictly independent from each other. All observations were carried out in the dark field of a microscope (n.a. 0, 36).

If one places a minute amount of very fine powder, such as Fe, Ni, Mn, Cr, Sb, in the exact center of the lower magnetrode, one can see, as soon as the magnetic field is applied, that some of the particles move toward the upper plate, while others remain at rest. It is also possible to place some particles on the upper plate only. Of these some move toward the lower magnetrode as soon as the magnetic field is applied, while the others remain at rest. It is even possible to combine both experiments at the same time. One then observes that some of the particles move toward the north and some toward the south magnetrode, carrying charges opposite to those of the plates, to which they move. The particles arrange themselves on the magnetrodes in the direction of the lines of force and in needle-like masses parallel to each other and perpendicular to the plates. These needles are similar to those which were observed in non-homogeneous fields since De la Hire.[7] Since this

[1] M. Faraday, *Exp. Res. in Electr.*, Vol. I, VIII, 665, 1839.

[2] R. Norman, "A New Attractive," etc., Chapter VI, anno 1576; W. Gilbert, "De Magnete," etc., Book IV, Chapter VI, anno 1628.

[3] F. Ehrenhaft, *C. R.* (*Paris*), 190: 263, 1930; *Phys. Zeitschrift*, 31: 478, 1930; *Phil. Mag.*, XI: 140, 1931.

[4] J. C. Maxwell, "Treat. El. et Magn.," Ed., Oxford, 1873, art. 377–379.

[5] F. Ehrenhaft, *Jour. Franklin Inst.*, 230: 381, 1940; *Nature* (London), 147: 25, 1941; SCIENCE, 94: 232, 1941; *Jour. Franklin Inst.*, 233: 235, 1942.

[6] F. Ehrenhaft, *Sitz. Berichte der Wiener Ak. D. Wiss.*, 119 (IIa), 815, 1910; *Phys. Zeitschr.*, 11: 619, 1910; *Ann. des Physique*, Paris, 13: 151, 1940; *Philosophy of science*, 8: 3, 1941. "The Microcoulomb Experiment" (charges smaller than the electronic charge).

experiment can be performed without light as well, there is evidence of motion of matter under the influence of homogeneous magnetic fields in both directions in darkness too. It is remarkable that one can easily distinguish two kinds of motion if one makes the field slightly non-homogeneous, by putting the plates at a very slight angle. While all ferromagnetic particles move in the direction of the denser lines of force (M. Faraday[8]), thus laterally and non-reversibly with the field, some of them, the charged ones, at the same time also show a superposed motion towards the plates, reversing this motion with the reversal of the field. Instead of placing the particles on the basis of the magnetrodes one can suspend them in gas in the space between the plates and observe in very diffused light a movement towards both plates, which in many cases was reversed with the reversal of the field.

Moreover, even in liquids one can observe such movements, which can only be explained if one assumes the existence of magnetic charges. Colloidal particles, for example, of Ni[9] or powdered particles suspended in various liquids, such as water, castor oil and glycerine, move, when exposed to the influence of homogeneous magnetic fields, toward the gold-plated magnetrodes and are finally deposited on them.

This is evidence that there is a phenomenon analogous to the well-known phenomenon of electrophoresis (cataphoresis)[10] and which should be termed "magneto-phoresis." The micro-photographs show that the deposits are coagulated in similar manner as the deposits of electrophoresis. It is also possible to observe the movement of individual particles under the influence of homogeneous magnetic fields as well as homogeneous electric fields independent of each other. These observations showed that the particles behaved similarly in both fields. However, the difference could be particularly well noticed on Cu particles which moved only in electric fields, but not in magnetic ones and on some iron particles which moved in magnetic fields but not in electric ones.

In order to explain all the phenomena which one can observe on magnetic ions one has to make similar assumptions as in the interpretation of phenomena on electric ions (f.i. change of charge, space charges and double layers). Thus, the changes of direction and of velocity occurring frequently and spontaneously during the observations must be explained as changes of magnetic charge. Up to the present, artificial change of magnetic charge could be achieved by means of irradiation by light and by the application of friction. However, irradiation with radium which changed the electric charge easily did not alter the magnetic charge at all.

The discovery of magnetic ions led to the conclusion that Ampere's[11] hypothesis, stating that every magnet can be substituted in its effects by circular electric currents, can not be considered as valid in general any more, since one can not apply it to bodies, where an excess of magnetic charge has been proved by means of such simple experiments as were described above. It also led to the conclusion of the existence of the magnetic current mentioned before.

The unit of the magnetic current is defined as the flow of the unit of true magnetism through the unit of cross-section during the unit of time. It is understood that the unit of true magnetism is the magnetic charge which exerts a force of one dyne on an equal one placed at the distance of 1 cm in the vacuum.

Other experiments and important conclusions will be reported later.[12]

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[7] De la Hire, Memoir de l'Acad. Roy. des sciences des Paris, anno 1717.

[8] M. Faraday, *Exp. Res. in Electr.*, etc., Vol. III, XXI, 8455, 1855.

[9] F. Ehrenhaft, *Akad. Anzeiger d. K. Ak. d. Wiss. Wien*, July 10, 1902, No. XVIII.

[10] F. F. Reuss, Mem. Soc. Imp. des Naturalistes de Moscou, 2, 327, 1809.

[11] J. M. Ampere, "Exposé de Nouv. dec. sur. l'electr. et le magnet." Paris, 1822.

[12] The experiments described above were carried out at Carl Zeiss, Inc., New York, N. Y., where they can be demonstrated by the authors.

## NEW STEREOISOMERS OF METHYLBIXIN

THE pigment from the seeds of the Annato tree (*Bixa orellana* L.), bixin, $HOOC \cdot C_{22}H_{26} \cdot COOCH_3$, and its methylester, methylbixin, $CH_3OOC \cdot C_{22}H_{26} \cdot COOCH_3$, differ from most natural polyenes in their stereochemical configuration. It was found by earlier investigators[1] that Bixa pigments are labile forms which can be converted into the corresponding stable isomers by iodine, irradiation, etc. Therefore, the natural product and its ester must contain at least one *cis* double bond. Despite the elapse of a decade no further progress has been reported in this field. So far as we know, not even the reversibility of the conversion mentioned has been claimed.

In experiments carried out recently in these laboratories it was shown that numerous stereoisomers of natural[2] and synthetic[3] polyenes can be obtained in a

[1] P. Karrer, A. Helfenstein, R. Widmer and Th. B. van Itallie, *Helv. chim. Acta*, 12: 741, 1929; R. Kuhn and A. Winterstein, *Ber.*, 66: 209, 1933 and 67: 344, 1934; P. Karrer and U. Solmssen, *Helv. chim. Acta*, 20: 1396, 1937.

[2] L. Zechmeister, A. L. LeRosen, F. W. Went and L. Pauling, *Proc. Nat. Acad. Sci.*, 27: 468, 1941; A. L. LeRosen and L. Zechmeister, *Jour. Am. Chem. Soc.*, 64: 1075, 1942; L. Zechmeister and W. A. Schroeder, *Jour. Am. Chem. Soc.*, 64: 1173, 1942.

[3] L. Zechmeister and A. L. LeRosen, SCIENCE, 95: 587, 1942.