Design of a Basic Magnetic Circuit

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Abstract

The symmetry between electricity and magnetism suggests the possibility of magnetic currents. Theoretical considerations however, are believed to imply that such currents are impossible to be found in nature. Yet, the more we think about our 'raw' (unbiased by theory) knowledge of nature, the less asymmetry we observe between electrical and magnetic phenomena. That is why in this note I briefly propose a sketch of the simplest possible magnetic circuit, which is essentially possible to be tested by a well-equipped chemist.

Contents

1 Magnetic Wires

I argued earlier[1] that *a magnetic conductor should contain unpaired electrons.* This implies that **magnetic conductors are paramagnets.** The most stable examples of unpaired electrons are found on the atoms and ions of **lanthanides**. Since Gadolinium (Gd) has the most number of unpaired electrons, it probably is the best conductor of magnetism at room temperature.

Good conductors of electricity are diamagnetic. This suggests that *good conductors of magnetism (paramagnets) are dia-electric*, meaning that they are repelled by both poles of a strong electret.

Good conductors of electricity can also be said to be '*para-electric*', for they conduct electricity even if you exchange the poles of a battery. This implies that good conductors of electricity should be attracted by both poles of a strong electret.

1.1 Magneto-electret

Passing magnetic current thorough a coil of lanthanide wire should make it an electret, i.e. an electric dipole whose moment (polarization) is given by

$$\mathbf{p} = N I_m \mathbf{S}. \tag{1}$$

2 Magnetic Battery

A *magnetochemical cell* is quite similar to an electrochemical one: it consists of two 'magnetolyte' solutions, connected by a *paramagnetic-salt bridge*. There are two 'magnetodes' inside each solution, and a device to measure the resulting magnetic current.

2.1 Magnetolyte solution

An electrolyte usually consists of a salt dissolved in a polar solvent.

Similarly a *magnetolyte* solution consists of a lanthanide (paramagnetic) salt dissolved in a paramagnetic solvent.

2.1.1 Paramagnetic solvent

There are few paramagnetic liquid at room temperature. They include

- **Vanadium tetrachloride**, and
- **Magnetic Ionic liquids**, like *1-butyl-3-methylimidazolium tetrachloroferrate*[2].

2.1.2 Lanthanide salts

2.2 Lanthanide rods (magnetods)

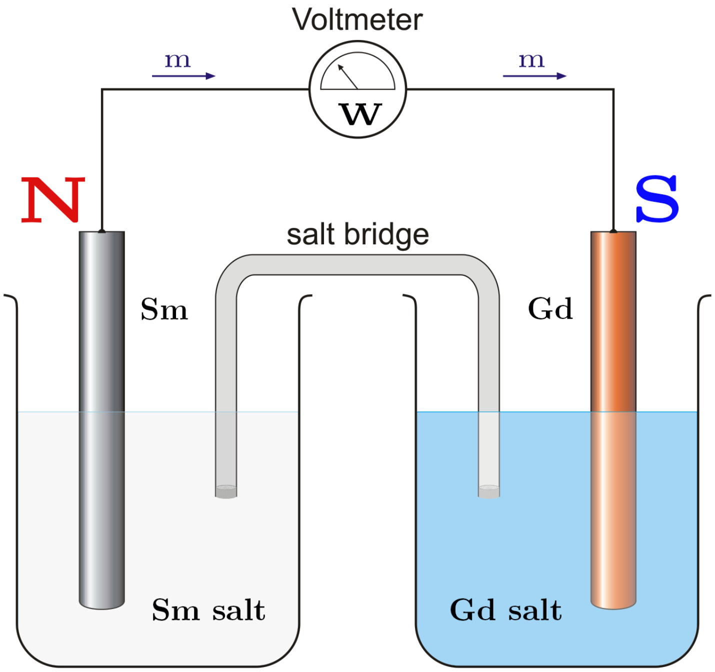

Figure 1: A Magnetochemical cell (Original unedited image from Wikipedia)

3 Measuring magnetic current

Electrets and Lanthanide wires can help us to build a device that measures magnetic current similar to a Galvanometer.

According to

$$\mathbf{F} = q_m(\mathbf{B} - \mu_0\epsilon_0\mathbf{v} \times \mathbf{E}), \tag{2}$$

a magnetic current moving through an electret would experience a force, given by

$$\mathbf{F} = -\frac{1}{c^2}\mathbf{J}_m \times \mathbf{E}.$$

This force can be employed to move a pointer.

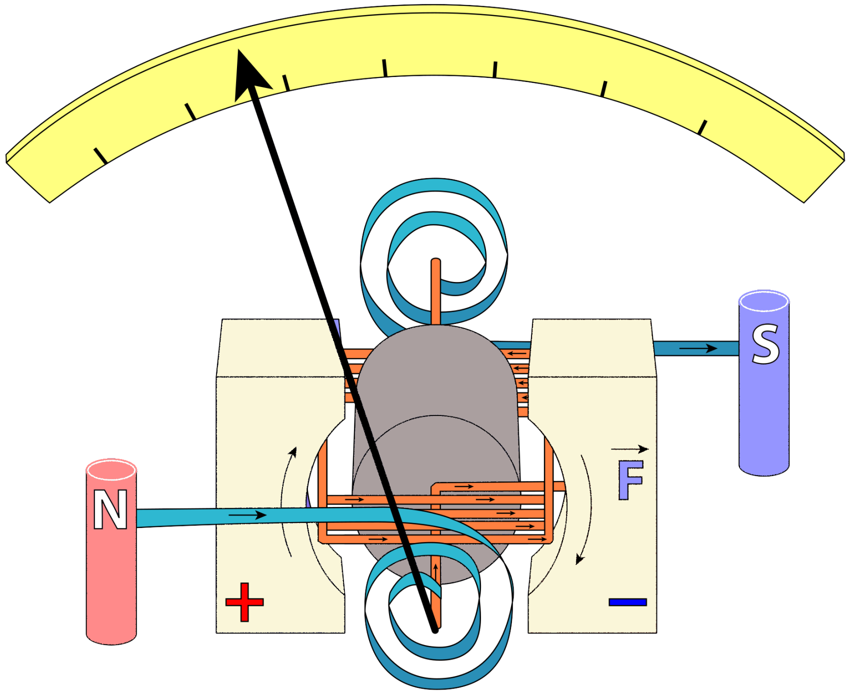

Figure 2: A magnetic-current-meter (Original unedited image from Wikipedia)

3.1 Ferroelectric compass

A lanthanide wire carrying magnetic current will create an electric field around it, given by

$$\mathbf{E} = \frac{1}{2\pi\epsilon_0}\frac{I_m}{r}\hat{\boldsymbol{\theta}}. \tag{3}$$

This enables us to visualize electric field lines using materials that are permanent electric dipoles. Ferroelectrics (e.g. Barium titanate) make this possible. The same idea can be the basis of a 'magnetocompass'. A ferroelectric needle suspended in a (ferro)fluid is essentially a magnetic compass.

References

[1] A. Jamali. Possibility of Magnetic Conduction. *viXra:2412.0048*, 2024.

[2] S. Hayashi and H. Hamaguchi. Discovery of a Magnetic Ionic Liquid. *Chemistry Letters*, 33(18), 2004.