

ELECTROMAGNETISM

Magnetic interactions

At this stage, you understand roughly as much about the classification of interactions as physicists understood around the year 1800. There appear to be three fundamentally different types of interactions: gravitational, electrical, and magnetic. Many types of interactions that appear superficially to be distinct --- stickiness, chemical interactions, the energy an archer stores in a bow --- are really the same: they're manifestations of electrical interactions between atoms. Is there any way to shorten the list any further? The prospects seem dim at first. For instance, we find that if we rub a piece of fur on a rubber rod, the fur does not attract or repel a magnet. The fur has an electric field, and the magnet has a magnetic field. The two are completely separate, and don't seem to affect one another. Likewise we can test whether magnetizing a piece of iron changes its weight. The weight doesn't seem to change by any measurable amount, so magnetism and gravity seem to be unrelated.

That was where things stood until 1820, when the Danish physicist Hans Christian Oersted was delivering a lecture at the University of Copenhagen, and he wanted to give his students a demonstration that would illustrate the cutting edge of research. He generated a current in a wire by making a short circuit across a

battery, and held the wire near a magnetic compass. The idea was to give an example of how one could search for a previously undiscovered link between electricity (the electric current in the wire) and magnetism. One never knows how much to believe from these dramatic legends, but the story is² that the experiment he'd expected to turn out negative instead turned out positive: when he held the wire near the compass, the current in the wire caused the compass to twist!

People had tried similar experiments before, but only with static electricity, not with a moving electric current. For instance, they had hung batteries so that they were free to rotate in the earth's magnetic field, and found no effect; since the battery was not connected to a complete circuit, there was no current flowing. With Oersted's own setup, [h](#), the effect was only produced when the "circuit was closed, but not when open, as certain very celebrated physicists in vain attempted several years ago."³

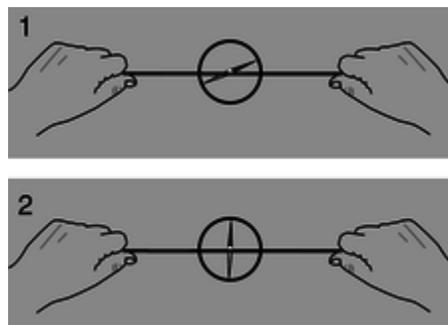


Figure 1. When the circuit is incomplete, no current flows through the wire, and the magnet is unaffected. It points in the direction of the Earth's magnetic field. 2. The circuit is completed, and current flows through the wire. The

wire has a strong effect on the magnet, which turns almost perpendicular to it. If the earth's field could be removed entirely, the compass would point exactly perpendicular to the wire; this is the direction of the wire's field.

Oersted was eventually led to the conclusion that magnetism was an interaction between moving charges and other moving charges, i.e., between one current and another. A permanent magnet, he inferred, contained currents on a microscopic scale that simply weren't practical to measure with an ammeter. Today this seems natural to us, since we're accustomed to picturing an atom as a tiny solar system, with the electrons whizzing around the nucleus in circles. As shown in figure [i](#), a magnetized piece of iron is different from an unmagnetized piece because the atoms in the unmagnetized piece are jumbled in random orientations, whereas the atoms in the magnetized piece are at least partially organized to face in a certain direction.

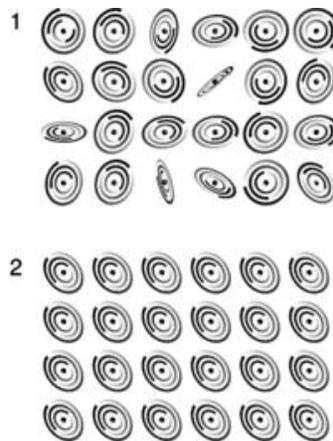


Figure i: A schematic representation of an unmagnetized material, 1, and a magnetized one, 2.

Figure j shows an example that is conceptually simple, but not very practical. If you try this with a typical vacuum tube, like a TV or computer monitor, the current in the wire probably won't be enough to produce a visible effect. A more practical method is to hold a magnet near the screen. We still have an interaction between moving charges and moving charges, but the swirling electrons in the atoms in the magnet are now playing the role played by the moving charges in the wire in figure j. Warning: if you do this, make sure your monitor has a demagnetizing button! If not, then your monitor may be permanently ruined.

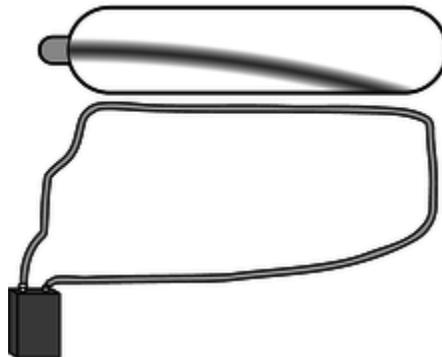


Figure j: Magnetism is an interaction between moving charges and moving charges. The moving charges in the wire attract the moving charges in the beam of charged particles in the vacuum tube.

Source:

http://physwiki.ucdavis.edu/Electricity_and_Magnetism/Fields/Electromagnetism