Lesson 16: Domain Theory

As mentioned in the last lesson, there are theories that we should be able to separate magnetic poles from each other, although no one has ever been able to actually do it.

- Instead, if a bar magnet is cut in half you get two *new* magnets, each with its own north and south poles.
- This means that any current theory of magnetism should be able to explain the **dipolar** nature of magnets.

This lesson is a bit iffy. Because the most modern theories predict the existence of monopoles, domain theory itself may eventually prove to be wrong. At present, it still serves as a good model of the behavior of magnets, especially at a high school level. In this way it is sort of like using the Bohr model of the atom in Chem; we know it isn't perfect, but it serves its purpose in our studies.

To do this, picture an atom as looking something like Rutherford's Planetary model, the one where electrons orbit the nucleus like little tiny planets around a sun.

- You can imagine the electrons as spinning around the nucleus, while at the same time spinning around on their own axis (just like the Earth as it goes around the Sun).
- For reasons that are not entirely understood, this **induces** a mini magnetic field all of its own.
  - Enough of these individual microscopic magnetic fields add up to act as a **domain**.
  - Each domain acts as a miniature magnet, with its own north and south poles.

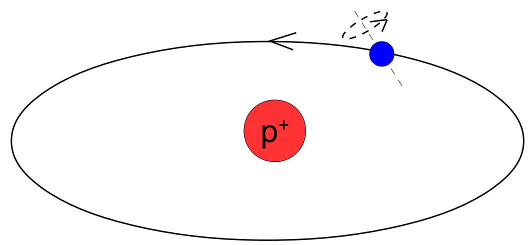

Illustration 1: Picture the electron as orbiting the nucleus, with the electron spinning on its own axis.

In most materials, these domains are random, pointing in all sorts of directions.

- Overall, randomly, these domains tend to cancel each other out.
- This explains why almost all materials are not magnets.
  - The domains start off random, and can ***never*** be aligned.

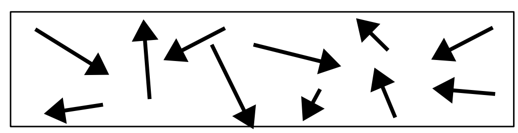
Illustration 2: Random domains result in no overall magentic field.

In ferromagnetic materials the domains *can* align.

- This does not mean that all ferromagnetic materials have to be magnetic. The domains might be random.
  - The difference for ferromagnetic materials is that they can align their domains.
    - This can be done by doing things like placing an existing magnet on the ferromagnetic material you want to align.

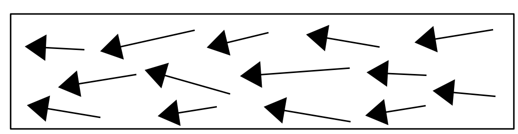
Illustration 3: Domains will mostly line up in magnets.

Warning!
Always remember that all matter contains electrons, so all matter has domains. If this is true, then why can't everything be a magnetic? The reason is that only ferromagnetic materials can rearrange their domains to line up. The exact reason for this property of ferromagnetic materials is not entirely understood.

The question comes up as to whether or not doing something to a piece of iron will make it a **permanent** or a **temporary** magnet.

- This depends mostly on how the metal is forged.
- If the domains are pretty much locked in place, then a **permanent magnet** will be formed. If this is done with iron, it is called **hard iron**.
- If the domains can be moved around easily, then **temporary magnets** will be formed. This would be **soft iron**.
    - Soft iron is useful if you want to make something like an electromagnet to pick up cars. It allows the magnetic field to be "switched" off and on. We will look at electromagnets in more detail later.

The terms "**hard**" and "**soft**" iron only refer to its magnetic properties. Neither of the two irons is actually physically harder or softer than the other.

Domain theory also gives us an easy way to look at demagnetizing an existing magnet.

- If you drop a magnet on the floor or strike it with a hammer, you are basically adding energy to the atoms of magnet.
    - Some of this extra energy will cause the atoms (and the electrons) to jiggle around more randomly.
    - This will screw up the alignment of the domains.
- Heating a magnet has pretty much the same effect, since raising the temperature will also increase the random motion of the electrons and domains.
    - Above a certain temperature, known as the **Curie temperature** (1043 K for iron), a magnet cannot be made at all.

Remember that "**K**" stands for "degrees **Kelvin**." To convert it to degrees Celsius, just subtract about 273°.

Homework

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