# Ferromagnetism

### Observations in Everyday Life:

Certain iron ores (*loadstone* or *magnetite*, $Fe_3O_4$) attract small pieces of iron. Any substance with this property is called *magnet* (after the Greek city of Magnesia).

Magnets can attract or repel each other.

A compass needle always points to the north.

### (Ferro-) Magnetism:

The fact that magnetic forces act on iron is called *ferromagnetism*.

### Magnetic Poles:

Similar to the situation in electrostatics, there are two types of magnetic "charges": the magnetic *poles*.

Every magnet has two different poles, a *north pole* and a *south pole*.

Like poles repel each other, and unlike poles attract.

There are no magnetic monopoles, i.e. no isolated north or south poles. If a magnet is cut in halves, each half possesses both poles again.

In addition to magnetic *dipoles*, there are higher order poles (e.g. *quadrupoles* or *octopoles*)

Contrary to electric charges, magnetic poles are not attached to freely moving charge carriers and therefore cannot easily be transferred from one body to another.

### Magnetic Attraction and Shielding:

Objects made of *iron*, *nickel*, *cobalt*, as well as alloys and compounds of these metals are attracted by a magnet, they are said to be *magnetisable*.

Magnetic fields can be shielded with a magnetisable plate.

### Elementary Magnets (Ampère):

Magnetisable substances consist of elementary magnets, which are oriented randomly. Therefore, there is no discernible magnetic effect on a macroscopic scale.

In a *permanent* magnet on the other hand, the elementary magnets are all oriented in the same direction, thus mutually amplifying the magnetic effect.

### Ferromagnetic Domains (Weiss Domains)

In ferromagnetic substances, the elementary magnets are oriented in the same direction across regions of typically $10^{17}$ – $10^{21}$ atoms, the *ferromagnetic* (or *Weiss*) *domains*. By aligning the ferromagnetic domains (e.g. in an external magnetic field), the object can be permanently magnetised (*remanence*).

To demagnetise a permanent magnet, the alignment of the ferromagnetic domains has to be destroyed, which can be done by heating the object over a characteristic temperature (*Curie temperature*).

### Magnetic Influence:

The elementary magnets in a magnetisable object placed near a permanent magnet align in the direction of the external field. As a consequence, the object becomes a (temporary) magnet itself, but loses this property as soon as the permanent magnet is removed.