FERROMAGNETIC ORDER

In ferromagnetic materials the atoms are arranged with their magnetic moments in parallel so that they supplement to each other. They have the same magnitude and in the same direction. Note that this ordered arrangement leading to spontaneous magnetisation decreases to zero at the curie point and above which the material becomes paramagnetic. The direction of alignment of the magnetic moments in a ferromagnetic material is normally along one of the crystal axes and the material is divided into magnetic domains usually of microscopic size each aligned with an axis of the crystal in which each of the atomic moments are aligned.

These domains are fully magnetised that they contain aligned magnetic dipoles resulting from spinning electrons even in the absence of the applied field. Between adjacent domains, there is a region of about 100 atoms thick, called domain wall.

In an un magnetised state the magnetic moments of the adjacent domains in a ferromagnetic material have different directions but it must be appreciated that the domain alignments may be randomly distributed in three dimensions and hence viewed as a hole.

ANTIFERROMAGNETISM

Some elements have strong coupling forces between the atomic dipole moments but their coupling forces produce anti-parallel alignments of the electron spins as shown in the figure above. The spins alternate in direction from atom to atom and result in no net magnetic moment. A material possessing this property is called antiferromagnetic. Antiferromagnetism is also temperature dependent in that when an anti-ferromagnetic material is heated above its curie temperature, the spin directions suddenly become random and the material becomes paramagnetic.

In general, in anti-ferromagnetic materials the dipoles point in opposite directions but the moments balance each other resulting in a net zero magnetisation.

FERRIMAGNETISM

These exhibit a behaviour between ferromagnetism and anti-ferromagnetism. Here quantum mechanical effects make the directions of the magnetic moments in ordered spin structure alternate and the magnitudes un equal resulting in a net non-zero magnetic moment.

Because of partial cancellation, the maximum magnetic flux density attained is substantially lower than that in a ferromagnetic specimen.

Read about:

- Curie-Weiss law.
- Hard and soft magnetic materials.
- Hund rule and Pauli exclusion principle.
- Hysteresis and coercivity as applied to magnets.