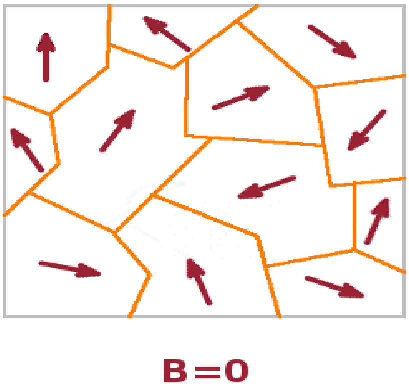
Weiss domain theory of ferromagnetism

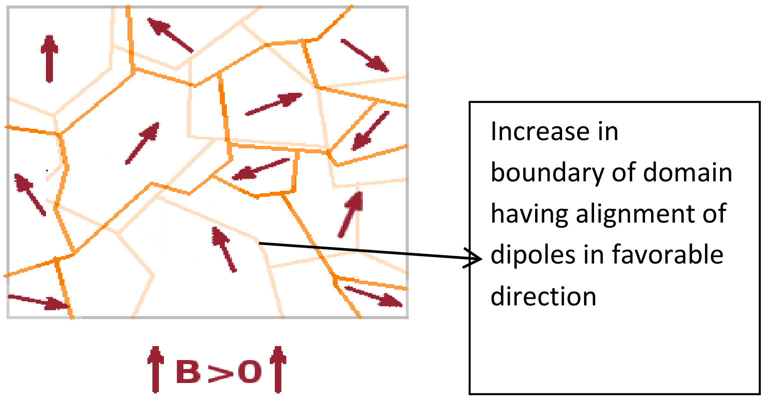
The Weiss theory of ferromagnetism assumes 1. the existence of a large number of small regions(width ~100nm) due to mutual exchange interaction called as Domains.2. that within a given domain there is spontaneous alignment of atomic dipoles.

The basic origin of these domains lies in the,' *Principle of minimization of total energy', * of the ferromagnetic specimen.

In all four energies come into play

1. Domain (Bloch wall energy) and Frustration energy.





Figure(a) random arrangement of dipoles in domains

Figure(b).movements of **Bloch walls** result in increase of magnetic potential energy

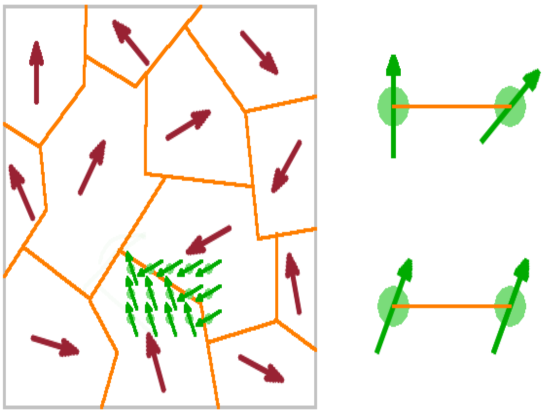
In absence of external field the orientations of the domains align s.t. total dipole moment is zero.Figure(a).

In presence of external field there in an net induced magnetization due to either

1. Increase in domain walls(Bloch walls) for those which have alignment parallel to the applied field at the cost of unfavorably oriented domains. **This predominant in case of weak fields wherein the boundaries of the domain do not recover their original dimensions once the external field has been removed.** **Figure(b) or by**

2. Majority of domains align/orient themselves parallel to the applied field. **This predominant in case of strong externally applied fields (*<u>make diagram yourself</u>*)**

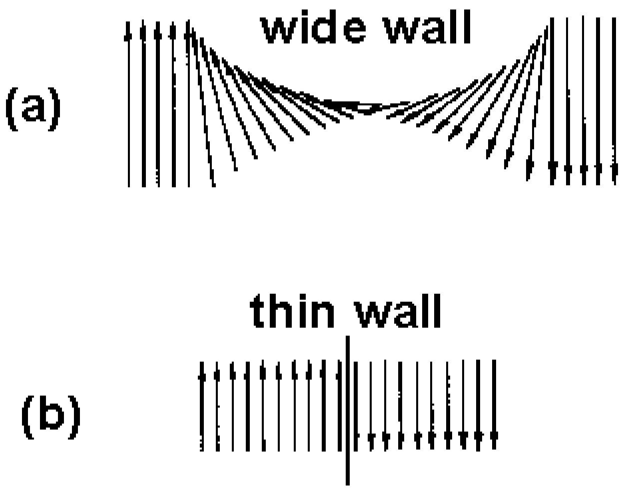
3.The Bloch walls surrounding the domains have no structure. The moments near the walls have an increased amount of potential magnetic energy as the neighboring domains produce an opposite field called as ,'Frustration'.



Orientation of atomic dipoles of one domain re-orienting in the favorable direction of neighboring domain the change is not abrupt

4. Near the walls the spin of atoms of one region get slowly oriented in the favorable direction of neighboring domain. (favorable means in direction of applied magnetizing field)

Now within the wall, the magnetization must change direction from that in one domain to that in the other domain. Domain walls have a finite width that is determined principally by exchange and magnetocrystalline energy.



Let's consider a domain wall in which the magnetization changes by 180°. The change in magnetization within the wall can be gradual as in (a) exchange energy is small or abrupt as in (b)wherein exchange energy is large.

2. Anisotropic energy

In crystalline solid it has been found experimentally that the relation between $\mathbb{H}$ and $\mathbb{M}$ depends on the direction of magnetization(direction in which $\mathbb{H}$ is applied).

Magnitizing iron is easier in [100] than in [110] and hardest along [111]

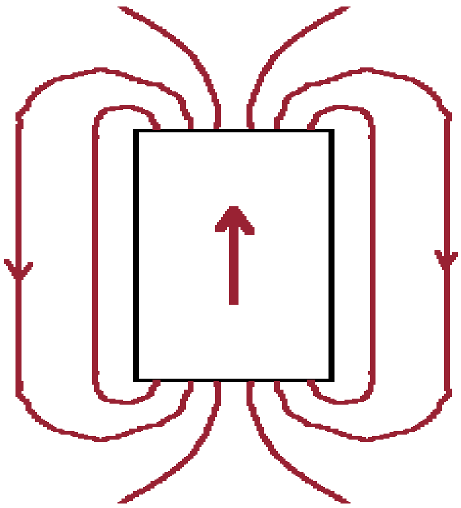
This difference in energy required to magnetize a crystalline iron(bcc) easiest[100] and hardest [111] is called as the crystalline anisotropic energy.*(Important The exchange*

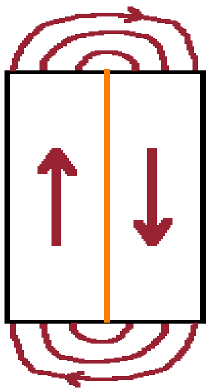
energy tends to increase the boundary of favorably aligned domains while the Anisotropic energy tends to reduce it due to these opposing forces the walls of the domains become finite ~100nm)

3. Magnetostriction Energy.

Experimentally it has been observed that when a paramagnetic specimen is magnetized it increases in dimensions .The deformation is different along different directions against the elastic forces and work done against it is equal to magnetostriction energy.

4. Magnetic Energy. It is defined as the interaction energy between two adjacent dipoles which comes into play when these adjacent align opposite to each other.





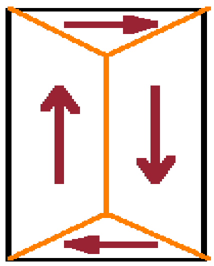


Fig1. Saturated domain — **Energy E**

Fig.2 for two opposite aligned domains — **Energy E**$/2$

fig.3 N no of domains — **Energy E**$/\mathrm{N}$

If we have a single domain and an external field is applied then the saturated residual magnetism thus produced would not only spread through the ferromagnetic specimen but also in the surrounding space. This is well contained by the structure of the ferromagnetic materials This spread is reduced by the growing opposition by the formation of opposite domains(having opposite alignment) such that the field lines of adjacent domains only connect at the end of the magnet. In addition to it there are terminal domains which confine the magnetic field to the specimen itself. This subdivision of domains continues till the magnetic energy becomes less than the energy increase due to the formation of another domain.