# Four Types of Magnetism and Critical Universality

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Now to two very important matters for us all to give serious consideration to, and hopefully exercise our talents accordingly.

If we want to prove to the world the rightness/validity of Reciprocal System, then we have to demonstrate its power, whenever we can.

Firstly, most texts only acknowledge three types of magnetism, but the fourth type, was discovered and elaborated on in 1932 by Louis Eugene Felix Neel, a French physicist, who died on 17$^{th}$ November 2000, 5 days before he would have turned 96. So the question automatically arises *re* RS and its explanation of all these four states.

Secondly, an inter-related matter. I shall quote from a letter, that a disenchanted member of ISUS once wrote to me, and I shall follow it with my own "start of an approach," in the almost vain hope that I may stimulate a reader with some knowledge on Critical points and Curie Temperature etc., to add to it.

Physicists have observed that several seemingly unrelated phenomena, e.g. the Curie Temperature in Ferromagnets, the Liquid-Vapor Critical Point, (where both phases become identical or indistinguishable) , and the Liquid-Liquid Critical Point, all have the same mathematical behavior.

This is termed **CRITICAL UNIVERSALITY**.

The System of Theory, to date, explains the three phenomena differently:

1. Liquid-Vapor criticality is the three-dimensional thermal vibration transition.
2. The other two are not well-defined, but certainly don't have as simple an explanation.

The problem is that from a physical point of view, there must be a reason for the same behavior in all three systems.

Accepted theory attributes the behavior to a statistical model, termed "Cooperative many-body effect."

The Reciprocal System of theory, so far, does not allow cooperative interactions between molecules in the unit distance region ($s = 1$ , $t \geq 1$).

**References**


- H.E. Stanley, *Phase Transitions and Critical Phenomena*, Oxford University Press 1971.
- C. Domb & M. S. Green eds., *Phase Transitions and Critical Phenomena*, Academic 1974.


Here are some definitions mainly from the Scientific Encyclopedia (Van Nostrand's)

## HYSTERESIS (Magnetic)

In general, the phenomenon exhibited by a system, whose state depends on its previous history. This term usually refers to magnetic hysteresis, of importance in alternating-current machinery. When a ferromagnetic material, such as iron, is placed in a magnetic field, a certain amount of energy is involved in bringing about its magnetization. If the field is a rapidly alternating one, the material may become noticeably warm. It appears that the repeated changes of orientation in whatever is within the substance, that responds to the reversals of field, are opposed by something like viscous friction. A quantitative study of the process indicates that, as the field intensity H increases, the magnetic induction B also increases in a manner, characteristic of the substance.

## PARAMAGNETISM

A physical characteristic of some matter, advantage of which is taken in certain instrumental systems and scientific apparatus. The paramagnetic qualities of oxygen, due to two unpaired electrons per molecule, is used as the basis for some oxygen analysers. Of the other common gases, only nitric oxide and nitrogen dioxide exhibit paramagnetism.

The elementary magnets of the atoms behave independently of one another when subjected to a magnetic field.

## DIAMAGNETISM

Diamagnetism is the phenomenon in which the magnetisation in a substance opposes the magnetising force, which induces it. Diamagnetism is considered to exist in all substances exhibiting paramagnetism or ferromagnetism; it is masked by the much greater opposite effect, due to the orientation of the magnetic atoms or molecules.

The elementary magnets of the atoms behave independently of one another when subjected to a magnetic field.

## FERROMAGNETISM

The property of certain materials that gives them relative permeabilities, noticeably exceeding unity, in practice from 1.1 to 1,000,000. Such materials generally exhibit hysteresis, hence can be used for permanent magnets. Ferromagnetism is an extreme case of paramagnetism, and results from the spontaneous alignment of the electron magnetic moments, associated with spin, even in the absence of an externally applied field.

## FERROMAGNETISM (Heisenberg Theory)

The exchange interaction between electrons in neighbouring atoms can be shown to depend on the relative orientations of the electron spins. If it should turn out that parallel spins are favored, there is a strong tendency for all the spins in the lattice to become aligned, the transition to the ordered state corresponding to the Curie point. The concept of localized spins (e.g. d-electrons in the transition metals) is confirmed by neutron diffraction, but the theory is incomplete at the stage of calculating the actual magnitude and sign of the interaction.

## ANTIFERROMAGNETISM

The observed susceptibility curves of certain substances suggest that the system has gone into a state analogous to the ferromagnetic state, but with neighboring spins antiparallel, instead of parallel. Such substances exhibit a paramagnetism, (low positive susceptibility), that varies with temperature in a manner similar to ferromagnetism, exhibiting a Curie Point.

Antiferromagnetism is a state, that can give a material important properties. In antiferromagnetic materials, which include certain metals and alloys, (e.g. lanthanum iron oxide), the magnetism from magnetic atoms, oriented in one direction, is canceled out by the set of magnetic atoms, aligned in the reverse direction. This magnetic state disappears at a specific temperature, the Neel Point (Neel Temperature).

## NEEL TEMPERATURE

The transition temperature for an antiferromagnetic material. Maximal values of magnetic susceptibility, specific heat and thermal coefficient occur at the Neel Temperature.

Four basic magnetic forces exist:

1) Paramagnetic 2) Diamagnetic 3) Ferromagnetic & 4) Antiferromagnetic

Ferromagnetic materials are much more permeable than a vacuum and thus positive, aligning with an applied magnetic field.

Diamagnetic materials are slightly less permeable, thus negative, aligning across the field.

Paramagnetism, ferromagnetism and antiferromagnetism diminish with temperature rise, whereas diamagnetism, essentially, is unaffected.

Precession of electron orbits in atoms and molecules, induced by an applied field, causes diamagnetism in all matter, even when paramagnetism dominates. Unpaired electrons in atoms or molecules cause paramagnetism and ferromagnetism. Normally, electrons of opposite spin pair off, netting zero magnetism per pair. Unbalanced spin moment of unpaired electrons yields both paramagnetism and ferromagnetism.

Paramagnetic matter has unpaired electrons in outer electron shells. Thermal agitation retards atomic or molecular alignment, and thus the net moment is weak.

Ferromagnetic matter, such as iron, cobalt and nickel, has unpaired electrons in the next-to-outer shell. Interatomic forces cause molecular alignment and permanent magnetism results.

## The Curie Point (or Curie Temperature)

Ferromagnetic materials lose their permanent or spontaneous magnetisation above a critical temperature, (different for different substances). This critical temperature is called the Curie point. Similarly, ferroelectric materials lose their spontaneous polarization above a critical temperature. For some such materials, this temperature is called the “upper Curie Point,” for there is also a “lower Curie Point,” below which the ferroelectric property disappears.

## Curie-Weiss Law

The transition from ferromagnetic to paramagnetic properties, which occurs in iron and other ferromagnetic substances at the Curie point, is accompanied by a change in the relationship of the magnetic susceptibility to the temperature. P. Curie stated in 1895 that above this point the susceptibility varies inversely as the absolute temperature. But this was found to be not generally true, and was modified in 1907 by P. Weiss to state that the susceptibility of a paramagnetic substance above the Curie point varies inversely as the excess of the temperature above that point. At or below the Curie point, the Curie-Weiss law does not hold.

## CRITICAL POINT

1) A point where two phases, which are continually approximating each other, become identical and form but one phase. With a liquid in equilibrium with its vapor, the critical point is such a combination of temperature and pressure, that the specific volumes of the liquid and its vapor are identical, and there is no distinction between the two states.

   At the critical point the molar volumes of the liquid and of the gas become equal. In general, a critical state is characterized by the fact that the two coexistent phases, (here the liquid and the vapor), are identical.

   The experimental data do not indicate the existence of a critical point for the liquid-solid transition.

   Above the critical point the substance can no longer exist in the liquid state. The critical temperature is thus the highest temperature at which the liquid and vapor can coexist.

2) The critical solution point is such a combination of temperature and pressure, that two otherwise partially miscible liquids become consolute (miscible in all proportions).