Stastical Physics Summer 2019

Lecture Introduction — 25.02, 2019

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1 Overview

In this lecture we discussed content of the lectures and some models of statistical physics.. . . .

2 Contents

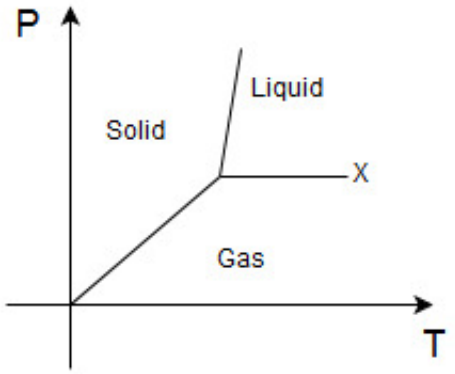
Class consists of lectures and laboratories. Table of contents for the lectures can be found at `http://wppt.pwr.edu.pl/studenci/karty-przedmiotow`. Topics include thermodynamics, partition function, Ising model, liquid crystals, melting process, polymers, Landau theory, quantum mechanics, usage of statistical physics in social experiments nad systems in non-equilibrium.

3 Models

At the first lectures we talked about simple models of physical systems. We mentioned system of atoms, system of spins and liquid crystals.

3.1 System of atoms

On the graphic below is shown phase diagram including all states and termination point, marked with X.



System at termination point is unstable and unpredictable. The three states can be characterized as such:

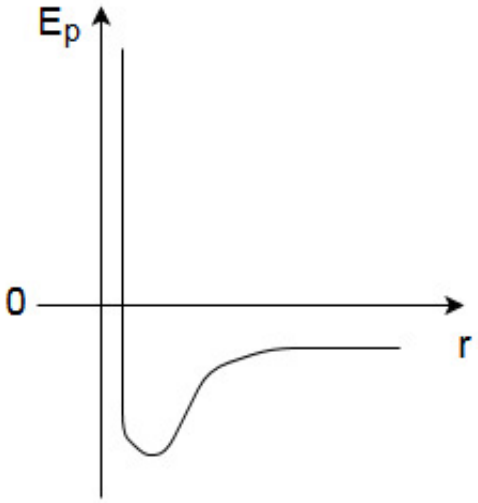
- Solid – atoms are tightly packed and dense

- Liquid – atoms are tightly packed but unorganized
- Gas – atoms are placed randomly, not dense

If the spaces between atoms are big (in atoms terms), does it mean we can say there are no interactions? Well, not really, but such simplification allows to make simpler models and sometimes simple models are good enough. As a rule of thumb, we can neglect interactions in gases, but they are very important and not neglectable in liquids and solids. Those interactions can be described using Lennard-Jones potential. (First bracket is repulsion part and second is attraction).

$$E_p(r) = 4\epsilon((\frac{\sigma}{r})^{12} - (\frac{\sigma}{r})^{6}) \tag{1}$$

This potential gives us graph shown below. Note this is a rough, handmade approximation of the function.



The negative energy means we have to use force, to move atoms either way.

3.2 System of Spins

Spin (for our purposes) is a vector. Let's assume two states - up and down. This means we have upwards vector $\vec{S}$=1 and downwards $\vec{S}$=-1. Let's assume spins describe small magnetic particles. Now we have all upwards vectors (or downwards), which basically gives us ferromagnet. We can have also mixed directions, but this results in 50% being upwards and 50% being downwards. We call this paramagnet.

Question What happens when we heat the magnet?

Answer Magnet properties devalue to the point where they disappear. This point is called Curie Temperature or Curie Point.

4 Liquid Crystals

Liquid Crystals are something in between solids and liquids. It flows, but when under microscope, one can see ordered structure. Molecules of LC are symmetric. We call it directors (vectors with two ends).When we heat it up, they become less ordered.