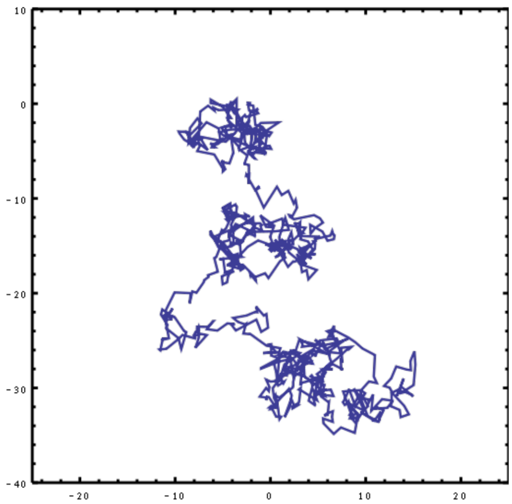
Statistical physics



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Objectives

Statistical methods allow to make the link between the physical laws applying on particules at the microscopic level and macroscopic physical systems where only the average of physical quantities and sometimes their fluctuations can be observed.
The student will learn the basic principles of statistical physics and how to apply them to physical systems in thermodynamical equilibrium. In particular they will learn how to derive the equation of state in astrophysical objects such as stars of different types, and how to obtain the ionization and excitation states of atoms in stellar and planetary atmospheres in thermodynamical equilibrium.

Evaluation

Type of examinations: A written exam (2 hours) will take place at the end of the lectures. A homework on applications of the course will be given to the students who will write a detailed report on the proposed subject by the end of the semester. Both works have a respective weight of 50% in the final grade.

Main progression steps

- First half of the period : theoretical courses (8 chapters).
- End of first half of the period : written exam.
- Second half of the period : Homework project.

Bibliography & Resources

https://hal.archives-ouvertes.fr/cel-01760602v1

http://mauca.unice.fr/index.php/documents-for-fc1-2-statistical-physics/.

Book: Statistical mechanics, Ryogo Kubo, Ed. John Wiley, North Holland

Contents

Part 1: Basics of statistical physics

by M. Faurobert

1. Chapter 1: Introduction
   (a) The microscopic world
   (b) Probabilistic description
   (c) Classical and quantic systems. Validity domains
   (d) Fundamental postulate
   (e) Some simple examples
2. Chapter 2: Equilibrium of isolated systems (micro-canonical ensemble)
   (a) Thermodynamic equilibrium
   (b) Statistical entropy
   (c) Equilibria between sub-systems of an isolated system.
3. Chapter 3: Systems in equilibrium with a thermostat and with a reservoir
   (a) Equilibrium with a thermostat (canonical ensemble)
      - Partition function
      - Free energy and thermodynamical functions
      - Examples
   (b) Equilibrium with a reservoir (grand canonical ensemble)
      - Partition function
      - Grand potential and thermodynamical functions
      - Examples
   (c) Evolution towards equilibrium and Minimum principle
4. Chapter 4: Identical particules
   (a) Identical and discernable particules
   (b) Boltzmann statistics
   (c) Grand-canonical description: Fermi-Dirac and Bose-Einstein statistics
   (d) Classical limit of quantum statistics, Maxwell-Boltzmann approximation

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Part 2: Applications of statistical physics

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1. Chapter 5: Maxwell-Boltzmann statistics. Classical gas

   (a) Partition function, internal energy, free energy
   (b) Specific heat and entropy of a perfect gas
   (c) Pressure and state equation
   (d) Real gas and Van der Waals approximation

2. Chapter 6: Ideal quantum gas of fermions
   (a) Fermi factor
   (b) Fermi gas at low temperature. Fermi energy and Pressure
   (c) Application to white dwarfs

3. Chapter 7: Ideal quantum gas of bosons
   (a) Bose factor
   (b) Bose temperature.
   (c) High and low temperature regimes

4. Chapter 8: Photon gas, thermodynamics of radiation
   (a) Black body
   (b) Planck law.
   (c) Thermodynamical properties of the black body radiation. Radiation pressure