Statistical Physics - opis przedmiotu

Informacje ogólne

Nazwa przedmiotu	Statistical Physics
Kod przedmiotu	13.2-WF-FizP-SP-S16
Wydział	Wydział Fizyki i Astronomii
Kierunek	WFiA - oferta ERASMUS
Profil	-
Rodzaj studiów	Program Erasmus
Semestr rozpoczęcia	semestr zimowy 2023/2024

Informacje o przedmiocie

Semestr	2
Liczba punktów ECTS do zdobycia	3
Typ przedmiotu	obowiązkowy
Język nauczania	angielski
Sylabus opracował	• prof. dr hab. Andrzej Drzewiński

Formy zajęć

Forma zajęć	Liczba godzin w semestrze (stacjonarne)	Liczba godzin w tygodniu (stacjonarne)	Liczba godzin w semestrze (niestacjonarne)	Liczba godzin w tygodniu (niestacjonarne)	Forma zaliczenia
Wykład	30	2	-	-	Zaliczenie na ocenę
Ćwiczenia	15	1	-	-	Zaliczenie na ocenę

Cel przedmiotu

The aim of the course is to familiarize students with the main issues of statistical physics which connects the microscopic and macroscopic worlds and constitutes the basis of thermodynamics. At the same time, the student should acquire the ability to understand and accurately describe various physical phenomena.

Wymagania wstępne

Passed courses "Fundamentals of Physics I, II" and "Quantum Physics I"

Zakres tematyczny

Lecture:

- *Thermodynamics*: concept of thermodynamic state, extensive and intensive variables, heat, work and internal energy, the first law of thermodynamics, concepts of entropy and temperature, Carnot engine, second law of thermodynamics, the fundamental equation, thermodynamic potentials: enthalpy, Helmholtz potential and Gibbs potential, the Legendre transformation, an *ideal gas*, the van der Waals system;

- *Phase transitions*: critical phenomena, the Clausius-Clapeyron equation, the order parameter, critical fluctuations, scale invariance and critical exponents, universality;

- *Kinetic theory*: kinetics of classical ideal gas, the *Maxwell–Boltzmann velocity distribution, degrees of freedom and the equipartition theorem, the Boltzmann equation, the H-theorem and irreversibility, the kinetic theory vs statistical mechanics*;

- *Classical statistical mechanics*: the ergodic hypothesis, the microcanonical ensemble, the *thermodynamic limit*, the *thermal* bath and canonical ensemble, the *partition function*, energy *fluctuations*, the grand canonical ensemble, the equivalence of thermodynamic ensembles, the Ising model and its applications;

- *Quantum statistical mechanics*: the Bose-Einstein and Fermi-Dirac statistics, pure and mixed states in quantum statistical mechanics, density matrix, the second quantization, quantum canonical ensembles, quantum ideal gases, the Debye model of vibrations;

Class:

- *Termodynamics:* thermodynamic processes, Carnot cycle, entropy in practical issues, equations of state for gases, magnetic systems and elastic systems, thermal equilibrium, specific heat;

- *Phase transitions:* critical phenomena for gases, magnetic systems and binary liquid mixtures

- *Kinetic theory:* mean square velocity of gas molecules and its relationship with gas temperature and pressure, mean free path, Maxwell velocity distribution, non-equilibrium processes;

- *Classical statistical mechanics:* the Gibbs paradox, thermodynamic potentials and their relations, partition functions and thermodynamic quantities, the one-dimensional Ising model, a simple model of paramagnet;

- *Quantum statistical mechanics:* the Fermi-Dirac and Bose-Einstein distributions, the occupation number formalism, the blackbody radiation, quantum harmonic oscillators, the electron gas;

Metody kształcenia

Classes are in the form of lectures where the student is encouraged to ask questions. On the exercises, students analyze and solve problems with a teacher.

Efekty uczenia się i metody weryfikacji osiągania efektów uczenia się

Opis efektu	Symbole efektów	Metody weryfikacji	Forma zajęć
The student knows and can apply the principles of thermodynamics for qualitative and quantitative analysis of simple physical problems.		• egzamin - ustny, opisowy, testowy i inne • obserwacje i ocena umiejętności praktycznych studenta	• Wykład • Ćwiczenia
The student has practical knowledge of the modern theory of phase transitions based on a phenomenological and microscopic approach. Using a phase diagram, the student is able to describe first-order and continuous phase transitions. The student understands the importance of the scaling hypothesis and the universality hypothesis, including their implications for critical phenomena in nature.		• egzamin - ustny, opisowy, testowy i inne • obserwacje i ocena umiejętności praktycznych studenta	• Wykład • Ćwiczenia
The student can relate microscopic models of classical and quantum multiparticle systems to measurable quantities, and based on the fundamentals of statistical physics can qualitatively and quantitatively analyze simple physical problems.		• egzamin - ustny, opisowy, testowy i inne • obserwacje i ocena umiejętności praktycznych studenta	• Wykład • Ćwiczenia
The student is able to determine the scope of application of classical and quantum models of ideal gases to describe real physical systems: a gas of photons in equilibrium or the specific heat of solids at low temperature.		• egzamin - ustny, opisowy, testowy i inne • obserwacje i ocena umiejętności praktycznych studenta	• Wykład • Ćwiczenia

Warunki zaliczenia

The exam is conducted in writen form. Student receives four issues to consider that require the knowledge of the issues and ability to combine various phenomena. For each task, one can receive from 0 to 5 points. To obtain a positive grade it is necessary to obtain at least 8 points (sufficient for 8-10.5 points, plus sufficient for 11-13.5 points, good 14-16, plus good 16.5-18.5 points, very good 19-20 points).

The basis of assessment exercises is attendance and passing written tests.

The classes must be completed before the exam begins.

The final grade is a weighted grade from two parts: exercises (40%) and final exam (60%).

Literatura podstawowa

[1] M. Kardar, „Statistical Physics of Particles", Cambridge University Press, New York, 2007

[2] L. Peliti, „Statistical Mechanics in a Nutshell", Princeton University Press, 2011

[3] M. Plischke and B. Bergesen, „Equilibrium Statistical Physics", World Scientific, Singapore, 1994

Literatura uzupełniająca

[1] M. Gitterman, V. Halpern, *Phase transitions. A Brief Account with Modern Applications*, World Scientific 2004.

[2] R K Pathria , P. D. Beale, „Statistical Mechanics", Elsevier, Amsterdam, 2011

[3] B. Poirier, „A conceptual guide to thermodynamics", John *Wiley* & Sons Ltd, UK, 2014

[4] F. Reif, „Fundamentals of Statistical and Thermal Physics", McGraw-Hill, New York, *1965*

[5] J. P. Sethna, "Entropy, Order Parameters, and Complexity", Oxford, 2006

[6] J. M. Yeomans, "*Statistical Mechanics of Phase Transitions",* Oxford Science Publications, 1992

Uwagi

Zmodyfikowane przez dr Marcin Kośmider (ostatnia modyfikacja: 16-10-2023 09:48)