UNIVERSITÀ DI PISA

DISORDERED SYSTEMS OUT OF EQUILIBRIUM

DINO LEPORINI

Anno accademico	2019/20
CdS	PHYSICS
Codice	309BB
CFU	9

Moduli	Settore/i	Tipo	Ore	Docente/i
SISTEMI DISORDINATI FUORI EQUILIBRIO	FIS/03	LEZIONI	54	SIMONE CAPACCIOLI DINO LEPORINI

Learning outcomes

Knowledge
The Course will provide basic knowledge concerning:

- Description and interpretation of disorder in liquids, colloids, glasses and polymers.
- Dynamics and thermodynamics of the off-equilibrium states in passive and active matter.
- Experimental techniques of current use in studies addressing the structure and the dynamics of disordered systems.

Assessment criteria of knowledge
The knowledge will be assessed by final oral exam.

Skills
At the end of the Course, the student will be able to understand and analyse scientific reports concerning experimental, theoretical and computational studies concerning the physics of disordered and off-equilibrium systems.

Assessment criteria of skills
Interactive lectures will be given to verify that the students are acquiring the technical and logic skills to understand the basic aspects of the physics of the disordered and off-equilibrium systems.

Behaviors
The student will be able to analyse scientific studies concerning the basic aspects of the physics of the disordered and off-equilibrium systems.

Assessment criteria of behaviors
Interactive lectures and final oral examination.

Prerequisites
Basic knowledge in Condensed-Matter Physics and Statistical Physics.

Teaching methods
Face to face lectures; possibility to discuss personally with the professor once per week; use of e-mail and e-learning site for communication and distribution of additional materials.

Syllabus

1. **from order to disorder**

- Long range positional order non-periodical: quasi-crystals

- Disorder in atomic systemswith long range positional order (cellular disorder)
    - Sostitutional disorder: inetrstitial and substitutional impurities, vacancies
    - Orientational disorder: plastic crystals (e.g. fullerene)

- Disoder in atomic systems without long range positional order (topological disorder)
    - Real crystals base elements:
        - Dislocations and Burger's vector,
        - Interfacial defects.
    - Liquid state and amorphous state
        - Distribution functions at n-bodies, particular case of pair distribution, static structure factor
        - Hard sphere atomic liquids: Percus-Yevick theory

- Disorder in polymeric systems
    - Conformations of linear polymeric chain: analogy with Random Walk
    - Chain rigidiy:Kuhn's segment
    - Distribution of dimensions of polymeric linear chain
    - Free energy of polymeric chain, entropic elasticity
    - Pair distribution function of polymeric chain: self-similarity

2. **From equilibrium to out of equilibrium**

- Metastable supercooled states and glass transition in liquids
    - Van Hove function and its momenta
    - Microscopic and collective dynamics: cage effect and vibrational properties, local and structural relaxation, relaxation times distribution, diffusion, viscoeleasticity
    - Elementary models of glass transition:
        - Free volume
        - Configurational entropy

- Elements of non-equilibrium thermodynamics
    - Zero Principle: fictive temerature in glasses, violation of fluctuation-dissipation theorem
    - Second Principle: Jarzynski's equality and Crooks fluctuation theorem: experimental tests in nano-systems

- Polymeric chain dynamics
    - Catena corta: modello di Rouse
    - Catena lunga: effetto degli aggrovigliamenti
        - Modello a tubo di Edwards
        - Moto di reptazione di De Gennes: argomenti di scala

- Cenni sugli stati di non-equilibrio nella materia attiva
    - Motori molecolari
    - Batteri, nuotatori, sciami: moti collettivi emergenti e transizione vetrosa

3. **Tecniche sperimentali: struttura e dinamica di sistemi disordinati**

- Scattering da sistemi disordinati: generalità
    - Sezioni d'urto di scattering, scattering coerente ed incoerente
    - Fattore di struttura statico e dinamico, scattering elastico e anelastico
    - Funzioni di correlazione spaziale, temporale e spazio-temporale

- Scattering di fotoni (raggi X e luce)
    - Sorgenti di radiazione coerente (sincrotrone), spettrometri e rivelatori
    - Struttura in sistemi disordinati: diffrazione di raggi X a largo e piccolo angolo
    - Dinamica in sistemi disordinati: scattering Brillouin e Raman, scattering anelastico di raggi X, spettroscopia di fotocorrelazione

- Scattering di neutroni
    - Sorgenti di neutroni, e rivelatori: tipici layout sperimentali.
    - Struttura in sistemi disordinati: diffrazione di neutroni a largo e piccolo angolo, confronto con i raggi X.
    - Scattering anelastico di neutroni e spettroscopia: TAS, TOF, Backscattering, Spin-Echo

Non-attending students info
None

UNIVERSITÀ DI PISA

Assessment methods

Final oral exam with interactive discussion.

Updated: 28/08/2019 10:13