230858 - MSM - Molecular and Soft Condensed Matter

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2018
ECTS credits: 4

Teaching languages: English

Teaching staff

Coordinator: Roberto Macovez
Others: Roberto Macovez
Carlos Enrique Alemán Llanso

Teaching methodology

Theory classes
Exercise classes
Description of some practical applications

Learning objectives of the subject

After taking this course, the students should be able to:
- based on the shape and size of its microscopic constituents, describe the types of condensed phases that can be displayed by a single-component systems, and ascertain which of them are observed at lower or higher temperature;
- describe the main experimental techniques available to identify phases and study molecular dynamics and phase transitions, and explain linear response theory and its main implications;
- discuss the degree of disorder inherent to a condensed phase, and its main characteristic microscopic dynamic processes; discuss the role of disorder and dynamics for rheological and mechanical properties;
- use random walk models and percolation and network theory to explain the properties of linear polymers and of polymer networks such as rubbers;
- describe the phenomenology of the glass transition in a number of systems ranging from atomic and molecular structural glasses to plastic crystals, to polymers and colloids;
- enumerate the main technological applications of molecular and soft condensed matter systems, and discuss the relevance of soft condensed matter to explain biological structure formation and biophysical processes.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 100h</th>
<th>Hours large group:</th>
<th>36h</th>
<th>36.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self study:</td>
<td>64h</td>
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<td>64.00%</td>
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## Content

### (1) BASICS ASPECTS OF ORGANIC CONDENSED MATTER

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 33h</th>
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<tbody>
<tr>
<td>(1a) introduction to condensed phases: microscopic constituents &amp; effective interactions; condensed phases: normal and supercritical fluids, crystals, glasses, mesophases; classification and examples of phase transitions (first order, continuous, glassy); van der Waals theory and isomorphic states; miscibility and binary systems</td>
<td>Theory classes: 12h</td>
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<tr>
<td>(1b) disorder &amp; molecular dynamics; linear response theory, dielectric and mechanical spectroscopy; other experimental techniques</td>
<td>Self study: 21h</td>
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**Specific objectives:**
- based on the shape and size of its microscopic constituents, describe the types of condensed phases that can be displayed by a single-component systems, and ascertain which of them are observed at lower or higher temperature;
- describe the main experimental techniques available to identify phases and study molecular dynamics and phase transitions, and explain linear response theory and its main implications

### (2) SINGLE-COMPONENT SYSTEMS

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<tr>
<th>Description:</th>
<th>Learning time: 40h</th>
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<tbody>
<tr>
<td>(2a) small-molecule condensed phases; crystallization kinetics &amp; polymorphism; structural glasses, ultrastable &amp; aged glasses; orientationally disordered solids &amp; plastic crystals; primary &amp; secondary relaxations; charge transport properties</td>
<td>Theory classes: 14h</td>
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<tr>
<td>(2b) bulk homopolymers; amorphous &amp; semicrystalline linear polymers; ideal chain statistics and entanglement effects, entropic spring constant, Rouse modes &amp; reptation; polymer glass transition &amp; crystallization; viscoelasticity; branched polymers &amp; networks, gelation and rubber elasticity, affine network model; conjugated and conductive polymers</td>
<td>Self study: 26h</td>
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<tr>
<td>(2c) thermotropic liquid crystals (nematic, smectic, columnar) and liquid crystal polymers; optical properties &amp; applications</td>
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**Specific objectives:**
- discuss the degree of disorder inherent to a condensed phase, and its main characteristic microscopic dynamic processes; discuss the role of disorder and dynamics for rheological and mechanical properties
- use random walk models and percolation and network theory to explain the properties of linear polymers and of polymer networks such as rubbers
(3) BINARY AND AQUEOUS SYSTEMS

**Description:**
(3a) Polymer solutions, non-ideal chains, theta-solutions, hydrogels; swelling phenomena; superhydrophobic/hydrophilic, superoleophobic, superamphiphilic, and self-healing polymer coatings; biopolymers, helix-coil & coil-globule transitions
(3b) Self-assembly in condensed matter: specific & non-specific interactions; block copolymers; colloidal systems (glasses, crystals, gels), surfactant-water systems, biomembranes, lyotropic liquid crystals, emulsions; semiflexible polymers & cytoskeleton.

**Specific objectives:**
- describe the phenomenology of the glass transition in a number of systems ranging from atomic and molecular structural glasses to plastic crystals, to polymers and colloids;
- enumerate the main technological applications of molecular and soft condensed matter systems, and discuss the relevance of soft condensed matter to explain biological structure formation and biophysical processes.

**Bibliography**

**Basic:**

**Complementary:**