MANO 1st semester Winter Workshop, 12-13 December 2019.

During the MANO Winter Workshop the students of the MANO curriculum are **warmly encouraged** to present a poster on a specific topic, a list of possible arguments is proposed below.
The posters will be prepared by groups of **two students**. The students will participate to the competition for the best poster award. Detailed instructions on how to prepare the poster will be posted on the website: https://corsi.unibo.it/2cycle/Physics/notice-board.
Besides the proposed topics, the students are free to propose their own topics that must be discussed in advance with one of the teachers of the first semester courses.
The student activity will be recognized with 3 CFU within the course: *Advanced Professional and Research Skills in Physical Science* through the presentation of a certificate of attendance.

Proposed Poster Topics

Course on "Symmetries, electrons and phonons"

1) *Molecular symmetries.* Describe and illustrate the symmetry operations forming the point group of selected molecules; report and discuss the character table of the corresponding point group. A useful web resource is http://symmetry.otterbein.edu/gallery/. There are numerous molecular graphics applications which can be used to make professional figures of molecular structures, including jmol (http://jmol.sourceforge.net/).
2) *Band structures.* Describe and illustrate the band structures $(\vec{k})$ of selected crystals, including at least one semiconductor and one metal. For each case describe the 1st Brillouin zone, highlighting the high symmetry points. For metals describe and discuss the Fermi surface. Useful web resources are http://www.xcrysden.org/doc/fermi.html and http://www.phys.ufl.edu/fermisurface/
3) *Failure of the harmonic approximation for lattice vibrations.* There are many physical effects which result from the failure of the harmonic approximation in the description of lattice vibration, such as thermal expansion, melting and finite thermal conductivity. Discuss these issues, including numerical estimates of the effects. Reference: Ashcroft and Mermin, chapter 25.

Course on "Magnetism and Superconductivity"

4) *Adiabatic demagnetization* Describe and illustrate the principle of the adiabatic demagnetization and its application to achieve low temperatures. Describe both the physical principles and how a real apparatus works by considering also some important field of application.
5) *Magnetic resonance spectroscopies* Describe the principles of one magnetic resonance technique and how it can be used to study magnetic or superconducting properties of materials.
6) *Production of Magnetic fields*. Describe how magnetic fields are produced, considering both permanent and electro-magnets, and how the record strong fields of several tens of Tesla can be achieved in hybrid conventional-superconducting magnets. Consider also some use of strong magnetic field for research or technological applications.

Course on "Laboratory of Condensed Matter Physics"

7) *Experimental apparatus for material characterization.* Choose one of the experimental characterization techniques illustrated in the course, based either on photon or particle probes

(electrons, protons etc.) Describe and illustrate the principles of the technique. Design the experimental apparatus needed to implement such a technique and describe the peculiarities of each chosen building block . If possible provide an estimate of the cost of the whole apparatus

8) *Material growth methods.* Choose one of the material growth/fabrication methods illustrated in the course, based either on the top-town or bottom-up approach. Describe and illustrate the principles of the technique. Select a recent scientific paper published in one of the following Journals: Nature Materials, Nature Nanotechnology, Nature Photonics, and critically analyze and comment the pros and cons of the selected growth/fabrication method.

Course on "Semiconductor Materials and Nanostructures"

9) *Lighting* Generating light emitters that operate at room temperature and at telecom wavelengths (around 1.55 microns) remains a significant materials challenge. To achieve this goal requires light sources that emit in the near-infrared wavelength region and that, ideally, are tunable to allow desired output wavelengths to be accessed in a controllable manner. Could you identify a semiconductor (including alloys and/or nanostructures) capable to emit at this wavelength? Could you discuss the relevant example? Select an example from the relevant scientific literature.

10) *Feynman Lecture* "There is a lot of room at the bottom… In this famous lecture given in 1959 R Feynman proposed several possible applications of nanomaterials [1]. How many of these applications have been done after more than 50 years? Please, describe an example from the relevant scientific literature.

    [1] https://pdfs.semanticscholar.org/1bc8/21e55e3b381eaba62bb02c861b9cb5273309.pdf

11) *Low dimensions in semiconductor physics*. New and interesting physical properties (optical, electronic..) arise when a semiconductor goes to "nano". Please describe a relevant example (material or device) selected from the recent literature (review papers preferred).

Course on: "Microscopic Kinetics and Thermodynamics"

12) *Thermoelectric materials.* Thermoelectric phenomena are an illuminating example of the symmetry of transport properties. Thermoelectric materials have a high technological importance in energy conversion and harvesting and in sensing applications. After illustrating the basic principles of thermoelectricity, describe an energy-related application of thermoelectric materials. Possibly discuss the atomic-level structure or nanostructure of a thermoelectric material of current interest. *(In addition to the course material, a review articles of thermoelectric materials is available for students interested in addressing this topic).*

13) *Atomic diffusion in nanostructures.* Describe the driving forces and fluxes that govern matter transport via diffusion in materials with a compositional gradient, illustrating the relevant atomistic mechanisms. Discuss one or two applications of these physical principles to the realization of nanostructures with peculiar morphologies, such as hollow and core-shell nanoparticles, in the light of recent (21st century!) research articles. *(A couple of examples are already available in the course material)*

14) *Nucleation phenomena in (nano) materials.* Underline the principles of nucleation theory as the key to understand a wide class of discontinuous transformations in materials. Discuss a prominent example of nucleation in traditional materials science (e.g. precipitation, solidification, shape memory effect) or in nanoscience (e.g. growth of nanoparticles from the vapor, formation of nanostructures on surfaces)