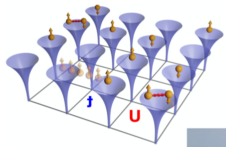
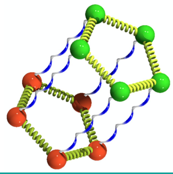
SCIENCES SORBONNE UNIVERSITÉ

MASTER Physique fondamentale et applications

SMNO nanomat master

M2 – SMNO-nanomat – AdvCMP

Title	Advanced Condensed Matter Physics (AdvCMP)	  
	Apogée code: MU5PYM11 **Number of credits:** 6 **Teaching hours:** 36h courses, 12h tutorial or project	

Lecturers	Benjamin LENZ IMPMC – Office 13-23.303 benjamin.lenz@sorbonne-universite.fr	Simon HUPPERT INSP – Office 12-22.504 simon.huppert@sorbonne-universite.fr

Objective	To gain knowledge of advanced physical properties of materials and their theoretical base beyond the independent electron concept. To investigate a number of challenging condensed phases such as superconductivity, Mott insulators, nuclear quantum effects, and related phase transitions. The most important experimental tools, in particular electronic and optical spectroscopies, will be discussed.
Content	• Linear response theory: o A reminder of second quantization and statistical concepts for solid state physics o Green's functions and linear response theory o Electronic screening (random phase approximation, Thomas-Fermi theory, etc.) • Electronic correlations: o An overview of important correlated materials and electronic interactions as seen through Green's functions: Quasiparticles, Fermi liquids, renormalization o The Kondo effect and the Anderson impurity model o Strongly correlated electrons: The Hubbard and t-J model • Nuclear quantum effects: o An overview over nuclear quantum effects (isotope effect, heat capacity, nuclei tunneling) o Path integral formulation of quantum statistical mechanics: PI molecular dynamics o Bose-Einstein condensation and superfluidity • Superconductivity: o Phenomenology (Meissner-Ochsenfeld effect, zero conductivity, perfect diamagnetism, London equations, type-I/II SC) o Ginzburg-Landau theory o BCS theory o non-conventional superconductivity at the example of cuprate high-Tc SCs A few tutorials will be proposed in which the students shall find numerical solutions to advanced problems treated in the lecture course. Examples include impurities in metals, Hubbard and t-J models, non-conventional superconductivity, and path-integral molecular dynamics simulations.
Prerequisites	- A good working knowledge of solid-state physics (Ashcroft & Mermin or Kittel level). - Quantum mechanics and statistical mechanics at the Masters 1 level. - Motivation to explore the most challenging states of matter and their theoretical concepts.
Examination	Final grade will be based on homework assignments, tutorial work, intermediary tests and one final oral presentation.