# M2 – SMNO-nanomat – AdvCMP

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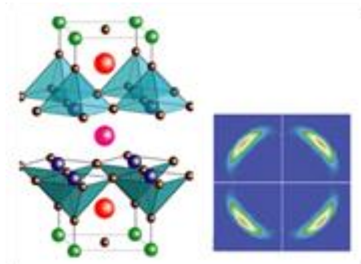
| Title | Advanced Condensed Matter Physics (AdvCMP) |  |
| | **Apogée code:** MU5PYM11<br>**Number of credits:** 6<br>**Teaching hours:** 40h courses, 12h tutorial or project | |



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| Lecturers | William SACKS (coordinator)<br>IMPMC – Office 22-23 – 403<br>william.sacks@sorbonne-universite.fr | Andrea GAUZZI<br>IMPMC – Office 13-23-411<br>andrea.gauzzi@sorbonne-universite.fr |



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| 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, magnetism, charge density waves, vortices, and more. The most important experimental tools, in particular electronic spectroscopies and materials characterization will be discussed. |
| Content | W. Sacks<br>• An overview of important superconducting and related materials<br>• Landau theory of second order phase transitions<br>• Exotic collective states: Superconductivity, vortices, Josephson effects<br>• Relevant theories: Ginzburg-Landau, London and BCS theories<br>• The cuprate high-Tc superconductors<br>• Important experimental techniques, photoemission and tunneling<br><br>A. Gauzzi<br>• Experimental evidence of interacting electrons<br>• Real gases of fermions and bosons.<br>• Interaction representation. Green functions. Feynman diagrams.<br>• Interacting electrons. Quasiparticles. Fermi liquids. Interaction function.<br>• Renormalisation effects. Electronic instabilities. Examples: magnetism and superconductivity.<br>• Strongly correlated regime: Hubbard and t-J models<br>A few tutorials will be proposed in which the students, guided by professors, shall find numerical solutions to advanced problems treated in the lecture course. Examples: Ginzburg-Landau and BCS equations of superconductivity, Hubbard and t-J models, etc. |
| Prerequisites | - A good working knowledge of solid-state physics (Ashcroft & Mermin or Kittel level).<br>- Quantum mechanics at the Masters 1 level.<br>- Motivation to explore the most challenging states of matter and their theoretical concepts. |
| Examination | Final grade will be based on homework assignment(s), tutorial work and one final examination. |