POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 41st cycle

THEMATIC Research Field: INVESTIGATION OF ELECTRONIC STATES IN 2D QUANTUM MATERIALS BY ARPES, IPES, EELS AND RIXS SPECTROSCOPIES

Monthly net income of PhDscholarship (max 36 months)
1500.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The abovEF project id FIS-2023-02406 CUP D53C24005490001 funded by MUR through the Bando FIS 2 (Fondo Italiano per la Scienza) as Advanced Grant, aims at building and operating an entirely new laboratory for electron spectroscopy of 2D quantum materials. The main novelty is the construction of an angle resolved inverse photoemission (ARIPES) apparatus working in the UV photon energy range with unprecedented resolution better than 40 meV. This system will be coupled to a more traditional Angle Resolved Photoemission system (ARPES) in the same range serving as reference technique. The availability of a monochromatic electron source (needed for ARIPES) and of an electron analyzer (for ARPES) allows the realization of Electron Energy Loss Spectroscopy (EELS) measurements on the same sample and in the same apparatus. The combination of ARPES, ARIPES and EELS can lead to a complete observation of electronic states both below and above the Fermi level in quantum materials with effectively 2-dimensional electronic structure. Moreover EELS can provide the 2 particle spectral function across the Fermi level. Finally, Resonant Inelastic X-ray Scattering (RIXS) performed with similar resolution at synchrotron beam lines, can complement the data measured at the “abovEF” lab by the determination of collective excitations such as phonons and magnons.
Methods and techniques that will be developed and used to carry out the research	The project has a strongly experimental approach, starting from the design of instrumentation, passing to its

	construction and commission, ending with its use for the study of quantum materials. The candidates will thus work on all these phases. In the first part of the PhD period, the instrumentation design activity will be complemented by RIXS experiments on 3d transition metal oxides, such as high Tc superconductors, nickelates, Fe oxides. Once the abovEF apparatus completed, the students will mostly devote their time and energies to measure ARIPES spectra on transition metal dichalcogenides an cuprates. For the design phase UV optics and electron optics calculations will be required, together with competences in motion control, signal acquisition, data analysis. The core of the project is however scientific: the ultimate goal will be to collect original data and to use them to address significant open questions on the symmetry of electronic states with respect to EF, in particular in superconductors. Thi project has the potential of opening completely new perspectives in the experimental study of quantum materials and has exploratory character.
Educational objectives	This project requires experimental and theoretical skills to be acquired, in particular in the design, commissioning and use of innovative instrumentation for electron spectroscopies in utra-high vacuum conditions (ARPES, ARIPES, EELS), in the use of RIXS spectroscopy at synchrotron beam lines, and in the analysis and interpretation of the results obtained. The candidate will develop competences in 3 fields of condensed matter physics, in addition to communication of scientific results and project management.
Job opportunities	The multiple competences will open opportunities in top level research groups worldwide in the same field, but also in labs and companies working scientific instrumentation.
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 3 PhD Students
Name of the research directors	Prof Giacomo Ghiringhelli; Prof. Marco Moretti

Contacts
giacomo.ghiringhelli@polimi.it, +39 02 2399 6067 https://orcid.org/0000-0003-0867-7748 www.polimix.fisi.polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Educational activities:Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences). Financial aid per PhD student per 3 years: max 6114,50 euros per student.

Teaching assistantship: There are various forms of financial aid for activities of support to the teaching practice.The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

Computer and desk availability: Individual use computer and desk