POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: STUDY OF NOVEL MATERIALS BY TIME AND ANGLE RESOLVED PHOTOELECTRON SPECTROSCOPY

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5 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 aim of this PhD project, in the framework of the Italian I-PHOQS infrastructure, is the development of novel experimental capabilities in the existing UPhOS (Ultrafast Photoemission and Optical Spectroscopy) laboratory for Time and Angle Resolved Photoemission Spectroscopy (TRARPES) at the Department of Physics of the Politecnico. TRARPES is an experimental technique that gives direct insight into the energy vs. momentum dispersion of electronic states as a function of delay after excitation by an intense pulse that brings the system out of equilibrium. The experiments contribute to the understanding of phenomena that involve several excitations inside the solid and that can be disentangled thanks to their different time evolution. Investigations involve a wide class of materials and phenomena, ranging from carrier dynamic in semiconductors (Roth et al 2D Mater. 6 031001 (2019), Hedayat et al 2D Mater. 8 025020 (2021)), electron-phonon coupling and lattice dynamics in correlated systems (Hedayat et al Phys. Rev. Research 1, 023029 (2019), Sterzi et al Phys. Rev B 94 081111 (2016)) and spin-texture in chiral systems (Gatti et al. Phys. Rev. Lett. 125, 216402 (2020), Hedayat et al Sci. Rep. 11, 4924 (2021)). In particular the main research line of this PhD project will be the investigation of charge density wave (CDW) in quasi-one dimensional (q1D) materials, such as ZrTe3, that exhibits an ordering at TCDW ~ 63 K. This material is an ideal case study for TRARPES due to its complex fermiology with states of different dimensionalities, strong

	momentum-dependent electron-phonon coupling and a large temperature-dependent renormalization of the band structure. All ingredients that contribute to the CDW, and whose weight will be quantitatively assessed in the energy, momentum and time domain.
Methods and techniques that will be developed and used to carry out the research	The actual experimental station allows performing experiments in the pump-and-probe mode using a 30 fs 1.8 eV photon pump and 70 fs, 6 eV photon probe. The pump triggers excitation that are studied by the detecting photoemitted electrons at subsequent times, with femtosecond resolution. At present, the low energy of the probe gives access to a very limited region of energy and momentum in the reciprocal space. The project of the PhD proposal is about extending the energy range of the probe photons up to 11 eV, allowing the detection of a much wider energy and momentum region while keeping the femtosecond time resolution. The experimental setup will follow a well-established scheme based on the 9th harmonic generation of the fundamental radiation of an Yb laser, through a phase-matched process in Xenon gas (Peli et al J. Electr. Spec. and Rel. Phenom. 243, 146978 (2020)): photons at 10.8 eV will be generated by focusing the third harmonics of the laser fundamental (1.2 eV) in a static Xe cell exploiting the negative dispersion regime of the gas. Part of the project will be dedicated to the design and installation of the light source, the largest part of the activity will be devoted to TRARPES experiments.
Educational objectives	The PhD student will gain full knowledge of non-linear optics and electron spectroscopy and will become familiar with Ultra High Vacuum techniques and with all aspects of TRARPES. The student will learn how to analyze data and will apply and widen physical knowledge needed to understand the results.
Job opportunities	At the end of the PhD, the successful student will be able to join research groups in related fields and to join companies where high technological skills and the ability of problem solving are required.

Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 0 PhD Students
Name of the research directors	Claudia Dallera, Ettore Carpene, Alberto Crepaldi

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	597.75 €
By number of months	6

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

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 4.872,90 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 availability: individual use
Desk availability: shared use