POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 40th cycle

PNRR 629 PNRR Research Field: STRAIN ENGINEERING OF NON-CONVENTIONAL SUPERCONDUCTIVITY IN CUPRATES AND NICKELATES

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 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	With reference to the *Piano Nazionale della Ricerca* (PNR 2021-2027), and according to the research priority actions on “nuovi materiali e nuove tecnologie per batterie ad alta capacità” within the “CLIMA, ENERGIA, MOBILITÀ SOSTENIBILE”, and on “Tecnologie quantistiche per la sensoristica e la metrologia” and “Tecnologie quantistiche per l’efficienza e la sostenibilità energetica”, within the “DIGITALE, INDUSTRIA, AEROSPAZIO” research and innovation areas, we will conduct research on the design of materials useful to reduce energy consumption and to enhance performances of electronic devices (*green ICT*).Oxide electronics is an established field since at least two decades, and transition metal oxides are already embedded in standard technology where their magnetic and piezoelectric properties are exploited. Behind, fundamental research is exploring new materials in search of more innovative applications. One branch is that of superconductors, in particular non-conventional ones, like cuprates, that offer critical temperature above liquid nitrogen temperature. Electronic devices base on superconductors can reach unconventional functionality and performances, in analoge and digital electronics, including quantum computation. And in a broader context, the ultimate goal of room temperature superconductivity is exceptionally attractive also for electric power transportation at zero losses over long distances. In this context, the research on cuprates and their recently discovered cousins, nickelates, that combine non-conventional superconductivity with strong spin-spin interactions, is as important as ever. The deposition of

	epitaxial films of these materials onto suitable substrates allows for the tuning of the uniaxial strain to be used to tune electronic and magnetic properties.
Methods and techniques that will be developed and used to carry out the research	In a collaboration with Dr Riccardo Arpaia at Chalmers University of Technology (Goteborg, SW) and Prof Sergio Caprara (Sapienza Università di Roma, IT), the PhD candidate will study how transport properties of cuprates (YBCO, LSCO) and nickelates ($ReNiO_2$) can be modified by strain and how these modifications can be explained at microscopic scale by the determination of electron-electron and spin-spin correlations and interactions using resonant x-ray scattering. The project imply the acquisition competences in thin film growth (PLD), structural and electric transport characterization, high resolution resonant inelastic x-ray scattering (RIXS) experiments, theoretical modeling within a dynamical Ginzburg-Landau model for frustrated charge density order.Growth and transport characterization will be done amilny at Chalmers, RIXS experiment at ESRF (Grenoble, FR) and Diamond Light soured (UK), theory at Sapienza University.
Educational objectives	This project requires experimental and theoretical skills to be acquired, from materials growth and characterization, to advanced spectroscopy, to theory. The candidate will develop competences in 3 fields of condensed matter physics in addition to communication of scientific results and project management. The multiple competences will open opportunities in top level research groups worldwide in the same field, but also in labs and companies working in oxide-based devices.
Job opportunities	This project requires experimental and theoretical skills to be acquired, from materials growth and characterization, to advanced spectroscopy, to theory. The candidate will develop competences in 3 fields of condensed matter physics in addition to communication of scientific results and project management. The multiple competences will open opportunities in top level research groups worldwide in the same field, but also in labs and companies working in oxide-based devices.

Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 3 PhD Students
Name of the research directors	G. Ghiringhelli, R. Arpaia, S. Caparara

Contacts
Prof Giacomo Ghiringhelli giacomo.ghiringhelli@polimi.it, +39 02 2399 6067https://orcid.org/0000-0003-0867-7748 Dr Riccardo Arpaia (Università di Venezia Ca' Foscari) Prof Sergio Caparara, Sapienza Università di Roma

Additional support - Financial aid per PhD student per year (gross amount)			
Housing - Foreign Students	**1st year**	**2nd year**	**3rd year**
	1000.0 € per student	1000.0 € per student	1000.0 € per student
	max number of financial aid available: 1, given in order of merit (only for students with scholarship)..		
Housing - Out-of-town residents (more than 80Km out of Milano)	**1st year**	**2nd year**	**3rd year**
	1000.0 € per student	1000.0 € per student	1000.0 € per student
	max number of financial aid available: 1, given in order of merit (only for students with scholarship)..		

Scholarship Increase for a period abroad	
Amount monthly	650.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	N.A
By number of months at the company	0
Institution or company where the candidate will spend the period abroad (name and brief description)	The ESRF - The European Synchrotron Radiation Facility (https://www.esrf.fr/)
By number of months abroad	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 5300 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*

Other information on Foreign Partner*: The ESRF - The European Synchrotron Radiation Facility (https://www.esrf.fr/) employs 650 people and is located in Grenoble (France). Chalmers University of Technology, Gotebrg, Sweden. https://www.chalmers.se/en/*