



## PhD in FISICA / PHYSICS - 39th cycle

### PNRR 118 PC Research Field: HYPERSPECTRAL IMAGING FOR THE STUDY OF COMPLEX ARTWORKS AT MULTIPLE SPATIAL SCALES

#### 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

Hyperspectral imaging enables the acquisition of data beyond what conventional colour cameras can capture. Indeed, by capturing spectral information across a broad range of wavelengths, hyperspectral cameras provide a wealth of additional data that can be used to uncover valuable insights. From environmental monitoring and agricultural assessments to industrial inspections and medical diagnostics, hyperspectral imaging has proven indispensable in various fields. Among them, since the 1990s hyperspectral imaging has emerged as a powerful tool in the field of art analysis, enabling researchers to gain valuable insights into the composition and condition of paintings, manuscripts, and other type of artworks. However, to fully exploit the potential of hyperspectral imaging, it is crucial to conduct analyses at different levels of spatial magnification. Indeed, the ability to rapidly modify the field of view through well-designed collection optics can enhance the versatility and utility of hyperspectral imaging in numerous applications. The present PhD call will explore the significance of integrating hyperspectral cameras with adaptable field of view (FoV) optics and will highlight their potential benefits in diverse domains of applications with a specific focus for the Heritage Science field. Indeed, different levels of magnification provide a comprehensive view of both macro and micro features present in a painting. At lower magnifications, the overall composition, brushwork, and general colour distribution become more evident. As the magnification increases, finer details, such as brushstrokes, texture, and individual pigment particles,



	can be examined. Hence, this multi-level approach ensures a more complete understanding of the artwork.
<b>Methods and techniques that will be developed and used to carry out the research</b>	<p>The present PhD project will specifically exploit an innovative hyperspectral camera recently patented by researchers of the Physics Department and the CNR-IFN. The camera is based on an innovative Fourier Transform (FT) spectrometer, the Translating Wedge-based Identical pulse eNcoding System (TWINS), coupled to a monochrome camera, that allows wide-field imaging together with high spectral resolution and accuracy. Thanks to its compactness, robustness and flexibility, the TWINS interferometer can be coupled to different imaging collection systems, spanning from standard photographic objectives to macro-lenses and microscope objectives. Within this context, the PhD candidate will design and study proper illumination and collection strategies to acquire hyperspectral images of the sample at very different magnifications, ranging from tenth of meters to tenths of centimeters and millimeters. He/she will study innovative collection optics that offer rapid modification of the FoV of the hyperspectral camera, considering solutions that allows the quick adjustments of the FoV without the need for physically moving the camera or the subject under analysis. Specialized optical systems, adjustable lenses, and precise focusing mechanisms will be considered as essential elements for capturing detailed images at different magnification levels. Further, different illumination strategies, including dark field illumination and the use of optical polarizers, will be studied to reconstruct accurate hyperspectral datasets in presence of surfaces with different roughness. Additionally, appropriate image calibration, noise reduction, and image registration techniques will be studied to ensure accurate analysis. The PhD candidate will finally assess how the examination of hyperspectral data at varying magnification levels can help in the quantitative analysis of pigment distribution in paintings. The PhD research project will be performed both in the ArtIS laboratory of the Physics department of Politecnico di Milano, where different prototypes of the innovative hyperspectral cameras are available, and in</p>



	Nireos Srl, a leading start-up based in Milano that develops and commercializes Hyperspectral imaging systems based on the patented TWINS interferometer.
<b>Educational objectives</b>	The PhD project will bring the candidate to the frontiers of research in the two following topics: - Design and testing of collecting optical system working at different optical magnification. - Design of an hyperspectral camera able to work at multiple spatial scales and its application to the analysis of artworks of different size (ranging from architecture facade to tiny artistic objects).He/she will also become an expert of the design of optical systems and will become familiar with the use of hyperspectral imaging for the remote sensing of surfaces.He/she will have the opportunity to be part of two dynamic and international research groups located at the Physics department of Politecnico di Milano.
<b>Job opportunities</b>	Due to the multidisciplinary training in optics, photonics and spectroscopy, the scholar will have excellent job opportunities in different types of companies and start-ups, including those designing optical systems and those developing spectroscopy and imaging spectroscopy systems. In addition, he/she will be well positioned for a possible career in university or research center.
<b>Composition of the research group</b>	1 Full Professors 2 Associated Professors 2 Assistant Professors 2 PhD Students
<b>Name of the research directors</b>	Daniela Comelli

<b>Contacts</b>	
Prof. Daniela Comelli: Daniela.comelli@polimi.it	

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



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

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Nireos Srl - <a href="https://www.nireos.com/">https://www.nireos.com/</a>
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	He/she will carry out a 6-months minimum secondment activity in an EU-located research group active in the development of cutting-edge mobile imaging instruments for remote sensing applications.
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p><b>Educational activities:</b> 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 <b>4.872,90</b> euros per student.</p> <p><b>Teaching assistantship:</b> 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.</p> <p><b>Computer and Desk availability:</b> individual or share use</p>