



## PhD in FISICA / PHYSICS - 39th cycle

### PNRR 118 PC Research Field: DESIGN AND DEVELOPMENT OF AN INNOVATIVE HYPERSPECTRAL CAMERA WITH EXTENDED SPECTRAL SENSITIVITY FOR THE STUDY OF ART OBJECTS

#### 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 SWIR range, typically spanning from 1,000 to 2,500 nanometers, allows for the detection of unique spectral signatures associated with various materials. Indeed, SWIR hyperspectral imaging has found successful applications in fields such as agriculture, to detect crop health and assess water quality in rivers and lakes, industrial inspection and quality control, to monitor and inspect pharmaceuticals, textiles, and processed food, and in surveillance and security applications. This spectral range is also particularly useful for analyzing pigments, dyes, and organic materials commonly found in cultural artifacts. By capturing reflectance data at numerous wavelengths within the SWIR range, hyperspectral imaging creates a spectral fingerprint for each pixel, enabling the identification and differentiation of different artistic materials. One further advantage of hyperspectral imaging in the SWIR range is its ability to penetrate surface layers and reveal hidden layers or alterations. The rapid advancement of camera technology has recently led to the development of new imaging sensors with sensitivity in the visible(VIS), near-infrared (NIR), and short-wave infrared (SWIR) part of the spectrum, paving the way for the development of innovative hyperspectral cameras sensitive in this wide spectral range.

##### Methods and techniques that will be developed and used to carry out the research

The present PhD project falls in this context with the aim of designing and developing a Hyperspectral imaging system with sensitivity in the visible to the short-wave



	<p>infrared portion of the electromagnetic spectrum. The PhD candidate will exploit an innovative Fourier Transform (FT) spectrometer, the Translating Wedgebased Identical pulse eNcoding System (TWINS), patented by researchers of the Physics Department and the CNR-IFN. The interferometer will be optically coupled to a monochrome camera with sensitivity in the desired spectral range to create a wide-field hyperspectral imaging system. The objective of the PhD research project presents certain unique challenges, specifically regarding:</p> <ul style="list-style-type: none"> <li>(i) the development of suitable collection optics for integration with the TWINS interferometer and</li> <li>(ii) the registration and calibration of images collected in this wide spectral range.</li> </ul> <p>Considering the first topic, a crucial aspect of the research will involve investigating and designing collection optics capable of minimizing chromatic aberration within the desired spectral range, also with the aid of computer-aided optical design tools and simulation software. This particular aspect of the project will leverage the valuable collaboration with Optec Spa, a leading Italian company specializing in optical, optoelectronic, and optomechanical fields. Considering the second topic, the PhD candidate will explore various techniques for image calibration, noise reduction, and image registration to ensure precise data analysis across the entire range of visible, near-infrared, and shortwave infrared spectra. Ultimately, the PhD candidate will explore how hyperspectral imaging within this extensive spectral range can contribute to the non-invasive study of artistic masterpieces.</p>
<b>Educational objectives</b>	<p>The PhD candidate will be at the forefront of research in two key areas:</p> <ol style="list-style-type: none"> <li>1. Development and evaluation of optical systems that operate across a broad spectrum.</li> <li>2. Creation and evaluation of post-processing techniques for datasets obtained through hyperspectral imaging.</li> </ol> <p>Additionally, the candidate will gain expertise in the application of hyperspectral imaging within the visible, near-infrared, and shortwave infrared spectral ranges. This knowledge will extend to its utilization in remote</p>



	sensing of various surfaces. Furthermore, the candidate will have the valuable opportunity to become a member of two dynamic and internationally renowned research groups situated at the Physics department of Politecnico di Milano
<b>Job opportunities</b>	Due to the multidisciplinary training in optics, photonics, spectroscopy and data analysis, 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

#### Contacts

Prof.ssa Daniela Comelli: Daniela.comelli@polimi.it

#### Additional support - Financial aid per PhD student per year (gross amount)

<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

#### Scholarship Increase for a period abroad

<b>Amount monthly</b>	597.75 €
<b>By number of months</b>	6

#### National Operational Program for Research and Innovation

<b>Company where the candidate will attend the stage (name and brief description)</b>	Optec Spa - <a href="https://www.optec.eu/">https://www.optec.eu/</a>
<b>By number of months at the company</b>	6
<b>Institution or company where the candidate will spend the period abroad (name and brief description)</b>	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.
<b>By number of months abroad</b>	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 **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 and Desk availability:***

*individual or share use*