POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

THEMATIC Research Field: HEXAPOD MOUNTING SYSTEM TO SUPPORT AN OPTICAL ELEMENT BASED ON SHAPE MEMORY ALLOYS

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 research is based on the possibility of using shape memory alloys (SMAs) to develop a hexapod mounting system to support an optical element. The purpose of this mount is to be used in extreme environments such as space to enable the actuation of optomechanical systems. The motivation lies in the growing need to reduce the cost of space missions and to increase the Technology Readiness Level (TRL) of emerging technologies. The concept involves creating a structure with SMA elements working in opposition to enable a reversible motion of the device. The potential application scenarios for this device are numerous, starting with all astronomical instruments mounted on satellites, as well as groundbased instruments. The advantages and motivations behind this study include: • The ability to create mechanisms without relatively moving mechanical parts, thus solving tribological issues, especially in space environments. • Reducing the mass of the payload for both space and ground applications by using high-performance geometries and materials. The critical aspects to be analysed are: • Ensuring structural stiffness while minimizing mass. • Limiting optical deformation during the operational phase of the instrument, avoiding stress during actuation. • Managing limitations related to hysteresis and structural changes due to multiple load cycles. The continuation of research on hexapod mounts is a key aspect, as it allows

	leveraging all the strengths of this kinematic scheme to ensure the stability of the payload. The research includes both mechanical and thermal considerations. Mechanically, it involves the arrangement of SMA elements to achieve reversible alignment configurations, utilizing both the superelastic properties and the shape memory effect. From a mechanical perspective, repeatability in positioning and low hysteresis are essential for proper functionality. Additionally, the device's natural frequency and its ability to actuate optics of various sizes are crucial for operations both in space and on the ground. On the thermal side, multiple challenges must be addressed: It is necessary to isolate the SMA components that should not be actuated, and to ensure that the heating of surrounding elements is not compromised. Thermal simulations and verifications must be performed, including assessment of the power required to actuate the system.
Methods and techniques that will be developed and used to carry out the research	The methods developed internally address several aspects, listed in order of implementation: • Research of the state of the art of materials and their constitutive models • Development of a parameterized geometry of the problem to determine sensitivity to the various quantities involved, including the implementation of sensitivity analyses • Iterations with the CNR (National Research Council) for the microscopic characterization of the properties and functioning of shape memory alloys Analysis of hexapod kinematics and implementation of the macroscopic characteristics of the material • Implementation of the material's constitutive law in accordance with the hexapod kinematics to actuate the optomechanical system • Static and dynamic analyses to verify functionality, both in terms of performance and actuation • Development of a thermo-mechanical model for heat dissipation • Design of the control scheme and power supply circuits • Software development

	• Prototyping • Testing and verification of requirements
Educational objectives	- Implementation of the constitutive laws of SMAs for the astronomical sector - Development of a functional device with broad multidisciplinary aspects - Testing and expertise in verification software
Job opportunities	Partners of the project are: • The research center of Brera Astronomical Observatory from National Institute of Astrophysics (INAF) •The National Research Council of Italy (CNR), based in Lecco Research abroad connected with the project will be possible at the European Space Agency (ESA), the European Southern Observatory (ESO) or other institutes working on the topic.
Composition of the research group	0 Full Professors 1 Associated Professors 2 Assistant Professors 6 PhD Students
Name of the research directors	Prof. Chiara Colombo, Dr. Edoardo Redaelli

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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
Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of € 6.114,50. Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 750 euro/month- net amount). Additionally, PhD candidates who spend at least 3 months abroad are eligible for an extra reimbursement of €3,000 to cover travel expenses. Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. 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.