Program Scheme

Activation within the PhD course in **PHYSICS** of the following Research Program, based on the resources referred to Ministerial Decree no. 351/2022, related to the following Measure:

[X] **M4C1- Inv. 4.1** *"Estensione del numero di dottorati di ricerca e dottorati innovativi per la pubblica amministrazione e il patrimonio culturale".* In particolar:

[X] **Dottorati PNRR**

- **Research Program Title**: Study of bioplastic degradation by prokaryotic organisms in seawater at extreme depths
- **Description** (MAX 5000 CARATTERI SPAZI ESCLUSI)**:**

Objectives:
Study of bioplastics degradation in extreme marine environments difficult to access in which a growth of micro/nanoplastics would mark irreversible changes to the ecosystem. Identical samples will be placed, for comparison, in coastal environments on a seabed a few meters deep and others in a plant municipal wastewater treatment to identify potential differences in degradation processes. A multidisciplinary team (physicists, chemists and biologists) will study the polymer degradation by separating the effect of pressure, light, temperature and oceanographic phenomena on the mesoscale and of biota on the bioplastic degradation. The project aims to identify the initial stage of bioplastic degradation with the release of nanoparticles, surface deterioration and modification of the polymer chain, taking into account that the environmental impact of the bioplastic degradation process in less accessible environments is more significant than that of production. Some samples will be placed at great depth by the INFN during the installation of technological equipment useful for experiments under construction and in agreement with the local regulatory bodies and municipalities.
The uniqueness of this project lies: 1) in the possibility of extending knowledge to extreme marine environments normally inaccessible to routine studies carried out near the sea surface; 2) in the analysis of degradation processes at the nanoscale with advanced analytical techniques generally used for nanostructured materials.
Coherence of the proposed program with the chosen Measure*:*
The project is consistent with the "*punto M2C4 investimento 3.5 della Missione 2 Rivoluzione verde e transizione ecologica del PNRR"* and aims at: 1) identifying procedures and interventions for the protection of the seabed and marine habitats in Italian seas and in particular in the heart of the Mediterranean Sea, on the eastern coast of Sicily; 2) reverse the trend towards the degradation of Mediterranean ecosystems caused by the presence of plastics thus favoring the maintenance and sustainability of fundamental activities not only for coastal areas but also for the country's essential production chains (fishing, tourism, food, blue growth).
Impact of the research:
The program to be developed within the PhD in Physics at UniME and IMM (Catania Headquarters section), in collaboration with INFN-LNS, complies with the objectives set by the European Green Deal and the PNRR. The results will have an impact in terms of:

(i) improvement of environmental sustainability: definition strategies for the production of plastic which is effectively biodegradable in water and for its correct disposal deriving from land activities (Goal 14.1 of the UN 2030 Agenda for Sustainable Development).

(ii) Acceleration of digital transformation processes: use of measurement systems at the nanometer scale for the nanoplastics detection in the marine environment and simulation of plastic degradation: from micro to nanoplastics.

(iii) promoting the social inclusion: development of strategies ensuring the preservation of seas vitality and eco-diversity. The figure of the PhD student will increase the awareness of young people towards this problem making them actors in the implementation of targeted R&D activities to reduce, recycle and reuse plastics.

Educational and research activity:

1) *Educational activity:*
   - Lectures / seminars given by the PhD course in Physics.
   - Training seminars / schools on GREEN themes.
   - Training courses aimed at encouraging the exchange between the world of research and that of production.
2) *Research activity:*

The PhD student will acquire specific skills in the characterization of polymeric materials with the most advanced characterization techniques, generally used for the study of materials used in electronics that today they even essential in the study of degradation phenomena at the nanoscale, together with conventional biochemical characterization techniques (chromatography or calorimetry). Between them: 1) low energy transmission microscopy (TEM) to avoid damage to "soft" materials such as plastic, associated with chemical (EDX) and spectroscopic (EELS) techniques necessary to identify the sample composition; 2) surface analysis techniques such as atomic force microscopy (AFM) and X-ray photoelectron spectroscopy (XPS) and vibrational spectroscopy techniques (Raman, FTIR).

Comunication and Dissemination activities:

Promotional activities will be carried out to increase the visibility of the project results and their technological and social implications. This will allow to interact with specific stakeholders favoring the transfer of project results and their exploitation. It is expected to do:

- Periodic reports on the activities carried out and round tables between researchers and stakeholders, including regulatory bodies, to share the development of the project and facilitate the exploitation of the results.
- External communication actions taking into account the segmentation of the target audience into three specific targets: scientific community, stakeholders, civil society.
- Activities at secondary school, including those of the PCTO, to raise awareness among students on the specific topic of the doctorate and introduce them to multisciplinary research in the physical-chemical-biological field.
- Communications on social media and participation in scientific conferences, round tables organized by sector entrepreneurs and public bodies.

❖ TIME TO BE SPENT AT ENTERPRSE– RESEARCH CENTERS – P.A.:

The research program will be carried out in collaboration with the following subject:

Ragione sociale: Istituto per la microelettronica e microsistemi (IMM) Sede legale: Strada

VIII, n° 5 (Zona Industriale) - 95121 Catania (CT)
Rappresentante legale: Dr. Vittorio Privitera

The aforementioned institution will host the PhD student beneficiary of the scholarship financed on the resources of the DM DM 351/2022 for n. **8** months **(min 6 max 12)** during the PhD course.

❖ PERIOD ABROAD

The research program provides for a period abroad of **n. 6 months (min 6 max 18)** at the following institution:

SINTEF Ocean, Trondheim, Norway

We also declare that this program complies with the principle "not to cause significant damage" (DHSH) pursuant to art. 17 of regulation (EU) 2020/852 in coherence with the technical guidelines prepared by the European Commission (Communication of the European Commission 2021 / C58 / 01) and guarantees compliance with the horizontal principles of the PNRR (contribution to the climate and digital goal so-called tagging, the principle of gender equality and the obligation to protect and enhance young people).