Proposal of Erasmus+ Traineeships

Faculty of Exact and Natural Sciences,
University of Zielona Góra

Designing and characterization of mechanical metamaterials

Supervisor:
Krzysztof Dudek (Institute of Physics, k.dudek@if.uz.zgora.pl)

Description:
Mechanical metamaterials are a class of structures capable of exhibiting counterintuitive mechanical properties such as auxetic behavior, negative stiffness or negative thermal expansion. Over the last thirty years, it has been demonstrated that these properties can be of great significance in the case of applications ranging from sports equipment to biomedical and protective devices. During the Erasmus+ Traineeship, the student will learn how to design mechanical metamaterials and characterize their behavior through the use of computer simulations based on the Finite Element Method (FEM). There will also be a chance to verify the validity of the computer simulations through the use of experiments corresponding to the mechanical characterization of 3D-printed samples. To this aim, the student will be provided access to a modern tensile loading machine.

Entry Requirements:
Basic knowledge of computer simulations utilizing the Finite Element Method (experience with the COMSOL Multiphysics software is an advantage)

Radiation Resistant Material Candidates for Drag Sail Technology

Supervisor(s):
Maciej Sznajder (Institute of Astronomy, m.sznajder@ia.uz.zgora.pl)

Description:
An increasing number of space debris become one of the main challenges for planning and deploying satellites dedicated to LEO, MEO, and GEO orbits. European Space Agency and its Clean Space initiative impose actions on future space projects to minimize the risk of generating new man-made non-functional satellite components. One solution to decrease the probability of producing space debris is deploying a drag sail whose primary function is to increase the drag coefficient of its host satellite, and hence, deorbiting the satellite in just a few years. The main component of the sail is its membrane. The main goal of this project is to find composite membrane material that would withstand a few years in the LEO radiation environment. The research activity will be based on data collected from a series of MISSE and LDEF space experiments as well as terrestrial laboratory activities on space materials.
Entry Requirements:
Basic knowledge of Linux, LaTeX and Python programming language.

Modelling of Quantum Wires and Waveguides

Supervisor(s):
Sylwia Kondej (Institute of Physics, s.kondej@if.uz.zgora.pl)
Wiktor Wolak (Institute of Physics, w.wolak@if.uz.zgora.pl)

Description:
This project focuses on the modeling of quantum wires and waveguides, a rapidly developing area of research. It is known that the geometry of quantum systems, such as quantum wires and waveguides, influences the spectrum of particles within these systems. The project examines scattering processes in specific types of wires or waveguides and analyzes resonance phenomena. During the Erasmus+ Traineeship, the student will gain familiarity with key results in the area of quantum wires and waveguides, reconstruct S-matrix and generalized eigenfunctions, and apply these findings to simulate particle behavior in these structures. The project combines analytical and programming tools.
Entry Requirements:
Basic knowledge of quantum theory at the undergraduate level, mathematics at the undergraduate level, and basic programming skills.

Modelling of Extrasolar Planetary Systems

Supervisor(s):
Andrzej Maciejewski (Institute of Astronomy, a.maciejewski@ia.uz.zgora.pl)
Maria Przybylska (Institute of Physics, m.przybylska@if.uz.zgora.pl)

Description:
According to the Extrasolar Planets Encyclopaedia, over 5000 extrasolar planets have been discovered, many within planetary systems. This project studies the dynamics of extrasolar planets. During the Erasmus+ Traineeship, the student will learn contemporary methods and tools for modeling and studying multi-planetary system dynamics. Training topics include:

1. Methods of planet detection
2. Fitting Keplerian orbits to observations
3. Models of multi-planetary systems
4. Numerical integration of N-body systems
5. Stability of multi-planetary systems

The project combines analytical and programming tools.
Entry Requirements:
Basic knowledge of classical mechanics, mathematics at the undergraduate level, and basic programming skills.

Self-Assembly of Metamaterials in the Drying Process

Supervisor:
Andrzej Drzewinski (Institute of Physics, a.drzewinski@if.uz.zgora.pl)

Description:
The evaporation of a liquid droplet on a solid substrate is a common phenomenon. For droplets of colloidal suspension, the drying process leaves a characteristic deposit on the substrate. This project investigates how various factors (surface morphology, solution pH, salinity, air humidity, temperature) influence deposit formation. Completing this project will broaden the student's understanding of applied physics.
Entry Requirements:
Knowledge of physics and mathematics at the undergraduate level.

Unraveling the Pulsar Emission Mechanism: Analysis of Single Pulse Observations from Polish LOFAR Radio Telescopes

Supervisor(s):
Wojciech Lewandowski (Institute of Astronomy, w.lewandowski@ia.uz.zgora.pl)
Rahul Basu (Institute of Astronomy, w.lewandowski@ia.uz.zgora.pl)

Description:
Pulsars are neutron stars with extreme properties, such as immense density and strong magnetic fields. Despite extensive research, their radio emission mechanism remains largely unsolved. This project provides an opportunity to analyze data from modern radio telescopes like LOFAR and the Giant Metrewave Radio Telescope in India, focusing on automating data analysis pipelines and scientifically interpreting the results.

Entry Requirements:
Basic knowledge of astronomy, electrodynamics, mathematics, and Linux programming skills.

Automation of Data Analysis Based on Exoplanet Observations

Supervisor(s):
Magdalena Szkudlarek (Institute of Astronomy, msz@astro.ia.uz.zgora.pl)
Michał Zejmo (Institute of Astronomy, michalzejmo@gmail.com)

Description:
Exoplanets have become a major field of research in modern astronomy. The ARIEL mission will observe 1000 exoplanets to survey atmospheric chemistry. This project, part of the ExoClock project, allows students to automate observation scheduling, data validation, photometry, model fitting, and data upload, using our PlaneWave CDK 20" telescope in Chile.
Entry Requirements:
Basic knowledge of astronomy and programming skills in Python.