Newsletter Interview

INNOVATIVE TECHNOLOGIES TO AID THE SEARCH FOR RARE PROCESSES

Interview with Andrei Puiu, researcher at the INFN Gran Sasso National Laboratories, winner of an ERC Starting Grant with the OPOSSUM project

Exploring the secrets of the universe by searching for a very rare process: this is at the heart of the OPOSSUM project, proposed by Andrei Puiu, researcher at INFN Gran Sasso National Laboratories, which the European Research Council (ERC) has funded with a Starting Grant of € 1.5 million. OPOSSUM aims to improve the sensitivity of experiments dedicated to searching for a process known as "neutrinoless double beta decay " which, if observed, would confirm that neutrinos coincide with their antiparticles, as predicted by Ettore Majorana.
The aim of the ERC Starting Grants, awarded annually and lasting five years, is to encourage the initial phase of researchers' careers and their most promising projects. They are, in fact, allocated to those who have between two and seven years of post-doctoral experience and work in a public or private research organisation with its headquarters in one of the European Union Member States or associated countries.
We asked Andrei Puiu to introduce us to the project he conceived.

Can you explain the OPOSSUM project to us and what its goals are?
The main goal of the OPOSSUM project is to improve the sensitivity of experiments that search for an extremely rare process, the so-called "neutrinoless double beta decay". In this decay, an atomic nucleus releases two electrons without emitting neutrinos, in contrast to what happens in standard double beta decay. If this phenomenon exists and were to be measured, it would allow us to confirm that neutrinos are Majorana particles, i.e. they are their own antiparticle, and it would also give us a measure of their mass.
In particular, OPOSSUM proposes a new method able to distinguish events related to double beta decay from background events, such as possible interactions between atomic nuclei and the alpha and gamma particles emitted by the detectors themselves, which are calorimeters operating at very low temperatures, close to absolute zero.
OPOSSUM aspires to open the door to the next generation of research for double beta decay and to continue current experiments, such as the CUORE project, currently active at the INFN Gran Sasso National Laboratories, pushing sensitivity to unprecedented levels, with the goal of answering one of the great questions of modern physics: what is the nature of neutrinos?

In your opinion, why did the ERC deem the project promising?
Obviously due to the name, OPOSSUM! Joking aside, I think the project was considered promising for two main reasons: its potential scientific impact and its technological innovation. Neutrinoless double beta decay research is, in fact, a crucial challenge in particle physics. If we were able to observe this decay, we could rewrite our

understanding of physics and find decisive answers to some of the universe's greatest mysteries, such as the nature of neutrinos and why the universe is composed predominantly of matter rather than antimatter.
To achieve this ambitious goal, OPOSSUM introduces a revolutionary technology. Using tellurium oxide crystals and innovative sensors, such as the so-called “Microwave Kinetic Inductance Detectors” (MKIDs), which provide unprecedented spatial and temporal resolution, OPOSSUM aims to identify the background of alpha and gamma particles in order to greatly improve the accuracy in the search for double beta decay events. OPOSSUM thus proposes a significant step forward in the techniques used to detect such rare events.

The ERC is a very competitive grant. What was the biggest difficulty you encountered in the selection process?
To be honest, the biggest difficulty was having little time to be able to prepare for the interview and, having no feedback between the first and second selection stages added even more pressure. Nevertheless, I was fortunate to receive excellent support, particularly from the INFN External Funds Department, which was crucial in preparing for the interview. In addition, my colleagues at the Gran Sasso Laboratories and the University of Milano-Bicocca, in particular Stefano Pirro, Luca Pattavina, Dounia Helis and Andrea Melchiorre, provided me with both valuable scientific and human support.

How will you invest the grant obtained? And what difficulties do you expect to have to face over the five years of the project?
The grant will cover the five years of the project, whose goal is the development of an innovative detector based on a new technology. The heart of the detector will be a tellurium oxide crystal, a material that has already been extensively tested and used in the CUORE experiment, but the big innovation of OPOSSUM lies in changing the paradigm of detecting interactions inside the crystal. Thus, the main technical challenge will be the construction of superconducting MKIDs directly on tellurium oxide crystals. This will be one of the most critical and innovative parts of OPOSSUM. I have already envisaged a number of alternative plans in case the initial solution is too complex or does not achieve the desired performance.
A key part of the project will, on the other hand, be dedicated to training a team of researchers, for which I will allocate approximately half of the total budget. The ERC allows me to recruit the best talents, and I believe that this team will be crucial to the success of OPOSSUM. On the management side, coordinating a research team is always a challenge, but I am confident in the abilities of the new generation of scientists, whom I consider even more well-prepared and resourceful than I am, despite being relatively young myself.

Let’s conclude with a personal question. What does it mean for you to have received this grant?
I oscillate between feeling flattered and the classic "impostor syndrome". Receiving such a competitive grant as the ERC is certainly gratifying and confirms to me that the work done so far has been appreciated. At the same time, I feel a responsibility to prove that I can live up to this challenge and the expectations placed on me. However, like true opossums, if things go wrong, I will play dead!

Andrei Puiu has a degree and Ph.D. in physics from the University of Milan Bicocca, where he had the opportunity to work with innovative detectors used for the HOLMES, CUORE and CUPID-0 experiments. He has been an associate professor at GSSI Gran Sasso Science Institute and has been a researcher at INFN Gran Sasso National Laboratories since 2022. During his career, he has developed innovative techniques for the detection of rare events at low temperatures, contributing to experiments of international significance.