Newsletter Interview

THE RELICS PROJECT, WHERE NEUTRINOS AND COSMIC MICROWAVE BACKGROUND MEET, IS AWARDED AN ERC GRANT

Interview with Martina Gerbino, researcher at the INFN Ferrara Division, winner of an ERC Starting Grant worth € 1.5 million.

The European Research Council (ERC) has awarded Martina Gerbino, researcher at the INFN Ferrara Division, a Starting Grant worth € 1.5 million for her research project RELiCS (Revealing Elusive LIght particles with Cosmic microwave background surveys across cosmological Scales). The project is dedicated to studying the properties of neutrinos and other light particles by creating a strong synergy between theoretical models and the data of several experiments dedicated to studying the cosmic microwave background (CMB), the oldest form of radiation that can be observed with our telescopes.

The European Research Council Starting Grants are awarded each year and were devised to encourage the initial phase of researchers' careers and their most promising projects. They are, indeed, 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. The 2023 ERC Starting Grants were announced on 5 September last year.

RELICS is a project at the intersection between theoretical and experimental physics and will be developed over 5 years. We asked Martina Gerbino to tell us about her goals and expectations for developing the project she has created.

Can you explain to us what RELICS is and what its goals are?

My project will study one of the most elusive essential components of our universe, neutrinos, exploring their still unknown properties, like their mass and capacity for interaction. It will also investigate the possibility that other, more exotic components of our universe, like dark matter or still unknown particles linked to open questions in fundamental physics, may be generated in eras that are very remote from the history of our universe. These studies will be conducted by looking far away in time, by using the observations of the oldest light that permeates the universe, the cosmic microwave background (CMB). For a long time, we've known that the way in which this radiation is distributed in the universe also depends on the properties of the mysterious

neutrinos. By reconstructing accurate maps of the CMB, RELiCS will look for answers to questions like: how many families of neutrinos are out there in the universe? How much do these particles weigh?

In your opinion, why did the ERC deem the project promising?

RELiCS aims to bring together two frontiers of physics research deemed particularly cutting-edge and with high potential for discovery: cosmology, with many new-generation experiments ready to start (including the key experiment for RELiCS, the Simons Observatory, being built in the Atacama Desert in Chile), and neutrino physics, with its essential, still unanswered questions. I think the ERC believed in RELiCS because its development might be compared to the creation of a bilingual dictionary through which these two worlds can speak correctly and easily.

How did you get interested in CMB? In your opinion, what can we still discover thanks to this radiation?

I've always been fascinated by the idea that CMB is a messenger from the past, that it has witnessed extreme phenomena in the primordial era, that it has wandered the universe for almost 13 billion years interacting with the enormous structures of matter in the formation phase, and that, having accumulated all this "experience", it can be captured to tell us thousand-year-old stories of eras and phenomena that are so distant in time and space. The very advanced experiments that we're constructing and that will start to collect data shortly will allow us to fully wring out our current knowledge of the universe: we have a standard cosmological model, the so-called "LambdaCDM" (where CDM is the acronym of Cold Dark Matter), which has functioned excellently until now. However, we know it is unsatisfactory in some truly important ways. For example, we still don't know what cold dark matter, or the "Lambda" cosmological constant are. The latter could correspond to mysterious dark energy, which permeates our whole universe. Using CMB, we can open and highlight cracks in this currently accredited model and go beyond it.

The ERC is very competitive funding that researchers from all the member states of the European Union aim for. Can you explain to us how the selection process works?

For me, obtaining this funding was a very long and challenging adventure but it was definitely exciting. I started to think about the project back in 2021 and I participated in the "ERC-Starting" call that year. Although the topic was deemed interesting, it did not pass the first step: the time wasn't yet ready, and neither was I. These last two years allowed me to acquire greater know-how and expertise, to better reflect on the purposes and methodology of the project and to refine and polish the writing of the proposal. This wait paid off.

The preparation for the interview was equally challenging: getting ready to defend your project in front of a commission of very expert people, competing for an enormous budget and with other very high-level colleagues is definitely frightening. The whole process, however, was useful to me for putting my work in perspective and understanding where I would like to be, professionally, in the near future. I'd say that's no small achievement!

How will you use the funding obtained?

A large part of the budget will be used to hire staff. RELiCS is highly multidisciplinary and will need support from very different professionals. It will range from mainly theoretical activities to data analysis and instrumental modelling, to the scientific analysis of data that requires advanced statistics skills. I'm expecting

to create a very diverse group that can integrate into the lively environment of the INFN division and the University of Ferrara and that, like me, is passionate about this type of research. A part of the budget will also be allocated to expanding local computing resources, since, for RELiCS to operate well, we need fast and continuous access to advanced computing resources.

What difficulties do you expect to have to face over the five years of the project?

We will definitely encounter technical difficulties: handling data, in general, and coming from such sophisticated instruments, in particular, is always more complex than what you predict. However, I'm sure that the experience I've gained over these years within international collaborations and the diversification of activities planned for the project will allow us to calmly deal with these potential difficulties. I also imagine that there will also be management difficulties: coordinating the activities of so many people and doing it while maintaining the fast pace required by the project will be a wonderful challenge. I am, however, certain that we'll manage to create the right atmosphere to happily collaborate for the success of the project.

What results are you expecting to obtain at the end of these five years?

Obviously, I hope that the universe is intriguing enough to hide an unexpected signal and that this project allows us to bring it to light in a clear and unequivocal way!

It would be wonderful to read about the existence of a new kind of particle or a new method of neutrino interaction in the maps of the CMB, and for these hidden treasures to allow us to clarify many, still misunderstood aspects of fundamental physics. If this doesn't happen, because nature has decided to operate differently, the project will still allow us to enormously improve our understanding of how the components of the cosmos have shaped the universe in which we live.

At a personal level, what does it mean for you to have received this funding?

It means gratification for the recognition and appreciation of the work I've done until now, it means feeling charged with so much responsibility, it means needing to prove that I have deserved trust, it means a huge opportunity for growth internationally. It also means immense gratitude to all the people who have trained me, who have believed in me, and are, therefore, co-responsible for this success.