## » INTERVIEW

### THE PHYSICS OF GRAVITATIONAL SIGNALS AMONGST THE L'ORÉAL-UNESCO 2021 AWARDS

*Interview with Ornella Juliana Piccinni, INFN researcher at the Amaldi Research Centre of the Sapienza University of Rome and member of the Virgo collaboration, winner of the L'Oreal-Unesco 2021 prize "Per le Donne e la Scienza" (For Women and Science)*

*Although the field of research dedicated to the study of gravitational waves is already preparing to launch a new season with even more powerful detectors, it continues to produce fundamental results, such as the one published in June by the Virgo, LIGO and KAGRA collaborations, dealing with the observation of the first signals generated by two mixed binary systems comprising a black hole and a neutron star. The work carried out by the many female scientists in this area of research is essential and indispensable for the achievement of such successes. This year they are in the spotlight of "Per le Donne e la Scienza" Italia, an international prize promoted by the L'Oréal foundation in collaboration with UNESCO, which since 2002 has aimed to raise public awareness of the problem of gender inequality in science, thus enhancing and supporting the work of young female researchers in the field of STEM disciplines (Science, Technology, Engineering and Mathematics) and encouraging new generations of women to embark on a scientific career. One of the six grants awarded in the 2021 edition of the prize went to Ornella Juliana Piccinni, a researcher at INFN Rome 1 division, at the Amaldi Research Centre of the Università Sapienza in Roma and a member of the Virgo collaboration, thanks to a project aimed at modelling and identifying the gravitational signals produced by magnetars, neutron stars with an extremely intense magnetic field.*

**How are the research projects of the L'Oréal prize selected and what kind of prize do the winners receive?**

Since 2002, L'Oréal Italia, in collaboration with the UNESCO commission, has annually selected the six most interesting research projects proposed by women under 35, in the field of life sciences, physical sciences and sciences relating to matter, including engineering and technological sciences. The "L'Oréal Italia Per le Donne e la Scienza" prize consists of a €20,000 scholarship for a 10-month project at a

## » INTERVIEW

research centre in Italy. The six best proposals from over 300 applications were selected by a jury of experts in the various research fields covered by the award and chaired by Lucia Votano, researcher at INFN, who also led the INFN Gran Sasso National Laboratories. In addition to the proposed project, the jury also took into account the candidates' curricula and any experience abroad.

**Did you expect to be among the winners and what did you think and feel when you received the news?**

Definitely not! For me it was a surprise, and what's more, it came at a fairly decisive time in my career. I remember that at that moment I was in the kitchen just about to drain the pasta, so I wasn't prepared at all. The first thing I did was to tell my family and colleagues, who had been telling me to try for years (and every time I found an excuse not to), so it was a great satisfaction.

**Your project concerns the research dedicated to the study of gravitational waves, which has achieved a number of incredible results in recent years. Can you tell us more about your project proposal?**

The research project I presented proposes a new line of analysis for a type of gravitational signal, not yet detected, which we call continuous gravitational waves. Typically, this signal is emitted by an isolated, asymmetric neutron star that is rotating rapidly on itself. So far there are several groups, even outside the LIGO-Virgo-KAGRA collaboration, that are trying to detect this signal, which is much weaker than the signal emitted during the merger of two black holes, two neutron stars or binary systems composed of both these bodies. So let's say there is a lot of competition, because many of us expect this to be the new surprise in gravitational astronomy. In detail, my project focuses on a particular type of neutron star, also known as a magnetar which has an extremely high magnetic field. In general, these objects can be formed following a merger between two compact objects, at least one of which is a neutron star, or else following the explosion of a supernova. The signal emitted by this particular system differs from what we would expect from a typical neutron star with a "normal" magnetic field, for example, in its duration, which we expect to be much shorter. Furthermore, the presence of extreme magnetic fields makes the star much more "asymmetrical" than a stable neutron star, and this in general relativity means that the star is theoretically capable of emitting a larger amount of gravitational energy. In general, even the very existence of magnetars, despite the confirmations coming from various studies, does not totally convince the entire scientific community. To date, there are about twenty known magnetars, others may be electromagnetically silent, which is why it is necessary to study these objects also through gravitational waves.

## » INTERVIEW

**What are the scientific objectives of your proposal and how do they fit into the future study of gravitational signals?**

We are currently in a crucial phase of gravitational astronomy. To date, several sources are missing from the detection list, including continuous waves generated by neutron stars. There is a great deal of excitement about this potential next discovery, because at the end of the ongoing upgrade phase the detectors themselves will have reached a level of sensitivity that enables them to pick up this particular signal, at least according to the estimates. In parallel, various research groups have significantly improved their search algorithms. So, we could definitely be on the verge of a first detection, which could once again prove Einstein right, if all the models we have considered so far are valid. If, in the next data run of the LIGO-Virgo-KAGRA collaboration, which is due to start next year, we don't actually manage to measure these signals, then it means that we have to start rethinking the models we have been using up until now, and this, after all, is still a way of helping to expand our boundaries of knowledge. In practical terms, I will have to work on a data analysis algorithm, optimised for finding signals from magnetars. The most exciting thing is to know that in case of detection we will be able to observe how matter behaves in conditions of extreme gravity and density, because I remember that neutron stars reach densities comparable with that of the atomic nucleus. To reproduce such an experiment on Earth with the technology available to us today would clearly be quite risky. Moreover, a possible detection could contribute to the observation of magnetars from the multi-messenger astronomy point of view, exactly as it happened with the first merger between two neutron stars (GW170817), we would also have gravitational waves available to study these objects that, to this day, we can only possibly observe through their electromagnetic emission.

**What was your study background and what motivated you to get involved in such a young field of research as gravitational waves?**

I always liked mathematics as a child and then astrophysics in high school. I enrolled in the three-year degree course in astronomy and astrophysics in Rome, but after a few months I switched to physics because there were too many interesting subjects and I wasn't sure of my path yet, so much so that my three-year dissertation was on a mathematical physics subject, i.e., tsunamis. Then, during my master's degree, the same thing happened, I attended astrophysics courses for a few months and then I switched to physics again, but this time I decided to include exams in my curriculum such as “General Relativity” and from then on it was love at first sight, it was the subject that perfectly combined my passion for mathematics with astronomy and astrophysics. I had decided that this was the subject that I was going to work on as my degree project, although initially I wanted to do something purely theoretical. In the

## » INTERVIEW

meantime, I had won an Erasmus grant for Germany in Hannover, so I plunged into this new adventure, under the guidance of Prof. Fulvio Ricci, former Virgo spokesperson and lecturer in the “experimental gravitation” course at Sapienza. In Hannover, I completed my master's thesis project at the Max Planck Institute for Gravitational Physics, in collaboration with the group of Dr. Maria Alessandra Papa, then a member of LIGO, with a project on gravitational waves emitted by neutron stars. After my master's thesis dissertation, it became natural for me to get in touch with the Virgo group in Rome where I did my PhD, this time in Astrophysics, working with Prof. Sergio Frasca and with the colleagues in Rome, continuing my research projects here.

**How do you evaluate the numbers of women in your research sector? Do you think that female researchers today have the same opportunities as their male colleagues or are there still inequalities related to career opportunities?**

Fortunately, I have always had the opportunity to work with women as well, but I do not deny that even looking at the situation in the Physics Department of Sapienza University, the percentage of female professors is drastically lower compared to their male colleagues.

The same is true if we look at large numbers: in the LIGO-Virgo-KAGRA collaboration, there are women but the most important roles, in most cases, are held by male colleagues. However, I recognise that at least part of the scientific community is beginning to address this gender gap in a serious way. In theory, the opportunities are available to all, but given the data on hand, many female students decide not to go on to higher degrees of education (starting with doctorates), and this clearly means that even fewer women get into positions of greater power, worsening an already alarming situation. There are some striking cases, even recent ones, of doctoral programmes consisting exclusively of male doctoral students. I would say that there are still disparities today, and that they mainly weigh on the most important period of a female or male scientist's career, and are very difficult to take up later. Certainly, in my opinion, this is a cultural problem that cuts across the different nations, so I would not speak of an exclusively Italian cultural problem. We grow up with models that do not fully represent us and that also direct us towards educational paths typically designed “for girls” and that do not necessarily provide access to higher education.

**What would you advise a young girl to do if she wanted to study physics or astrophysics after finishing secondary school?**

I would definitely say that it is the right choice and that there are no careers that are more or less suitable for one’s gender identity. That she should never be discouraged or feel uncomfortable when

## » INTERVIEW

she enters the classroom and realises that she is one of the few girls on the course, and that in no way this should be a burden on her career. In short, I would tell her that she can definitely do it.