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10 YEARS AGO THE BIRTH OF THE FIRST EUROPEAN INSTITUTE FOR THEORETICAL PHYSICS IN THE FIELD OF PARTICLE PHYSICS

Interview with Alberto Lerda, president of the INFN National Scientific Commission for theoretical physics and coordinator of the Galileo Galilei Institute (GGI) in Florence

The ceremony marking the tenth anniversary of the GGI took place on 17th May, on the opening day of the national conference on theoretical physics, in the historic seat of the Institute, on the hill of Arcetri. In the same place, a symbolic one for physics and astronomy, are also the National Institute of Optics, the Astronomical Observatory and Villa Il Gioiello, Galileo Galilei's last home, and as such recognised as a "historic site" by the European Physical Society in 2013. We talked to Alberto Lerda, coordinator of the GGI, about the activities promoted by the Institute and also touched briefly on the new frontiers of theoretical physics, in light of the most recent discoveries.

The *Galileo Galilei Institute* was founded ten years ago, an original and unique project on the European landscape. Where did the idea come from?
The GGI was born from an intuition of Giuseppe Marchesini, at that time president of the National Scientific Committee of the INFN for theoretical physics, who recently passed away. Together with some colleagues in Florence, he promoted the idea of creating a centre within the INFN dedicated to the organization of workshops and conferences on theoretical physics of elementary particles, based on the model of the Kavli Institute for Theoretical Physics in Santa Barbara in California, and located in the premises on the hill of Arcetri, which had become available after the University's Department of Physics moved to Sesto Fiorentino. Thus, the partnership between the INFN and the University of Florence produced the GGI, which started operations with an inaugural conference in September 2005 and held its first workshop in May 2006.

What activities does the GGI promote and implement? What have been the most important experiences in this decade of history, and can you please give us some numbers?
The GGI's main activity is to organize 6-8 week "extended" workshops, each one on hot topics in theoretical physics. So far 30 workshops have been organised with the participation of more than

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3500 physicists from around the world. The thirty-first workshop will begin next week and end in early July. The schedule of activities has already been defined for all of 2017 and in the coming months we will be receiving requests for 2018. Last year the GGI won a considerable grant from the American Simons foundation that will allow eminent scientists of world-wide fame to make extended visits to our workshops over the next five years. In between these activities, the GGI also hosts short seminars and conferences as well as partnership and committee meetings. Starting from 2013, the GGI has also organised a series of schools for doctoral students during the winter months. At the moment we have four schools (one for string theory, one for the phenomenology of fundamental interactions, one for statistical field theory and one for nuclear and hadronic physics). The number of students taking part (over 150 per year) continues to grow, and about half of them come from abroad. This is also a sign of the success that the GGI is having internationally.

Over the years, other similar centres have been created in Europe. What is the current scenario? Do the different centres collaborate with one another?
When the GGI was founded it was the only centre of its kind in Europe dedicated to theoretical physics. There were the Isaac Newton Institute for mathematical sciences in Cambridge in the UK and the Erwin Schrödinger International Institute for mathematical physics in Vienna, but there was no centre dedicated mainly to theoretical high-energy physics. Today, alongside the GGI, we have the Mainz Institute for Theoretical Physics and the Munich Institute for Astro and Particle Physics in Germany, the NORDITA in Stockholm and the programmes of the so-called TH Institutes at CERN in Geneva. All these centres complement one other and each one has its own characteristics and peculiarities. The GGI's particular characteristic is that it organises long programmes, even up to two months.

What are the main areas of research covered at the GGI?
In the early years, the GGI workshops were mainly focused on elementary particle physics, both of the Standard Model and its extensions, on quantum field and string theory and on what is known as astroparticle physics. In recent years, the scope of interest has widened to include statistical mechanics and nuclear physics and astrophysics. In other words, we now cover all the lines of research in theoretical physics addressed by the INFN. Next year we will also host a programme dedicated to cold atom physics and their use for simulations in gauge theories.

With the discovery of the Higgs boson, experimental researchers now have to change their approach: they must sail by sight and scan the horizon for signs of New Physics...
Yes, the discovery of the Higgs boson in 2012 completed the Standard Model in an amazing way, which seems to work very well, indeed, too well! As a matter of fact, all the properties predicted by the theory have so far been experimentally verified with great precision and without significant

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deviations. However, for various reasons, the Standard Model cannot be the final theory of fundamental interactions and the structure of matter and of the Universe: so scientists must look further. We are still missing a good explanation of the so-called dark matter, and of how gravitational interaction can be incorporated into the model. The data gathered in the coming months from the experiments of the LHC at CERN will be crucial to see if there are signs of new physics beyond the Standard Model. Compared to the past, however, the boundary conditions have changed, in the sense that, whereas before we knew we had to look for something like the Higgs boson, now it isn't clear exactly what we are looking for. Ironically, this uncertainty or wait might be even more stimulating and exciting, because whatever is discovered will almost certainly be something revolutionary.

This year we were announced yet another historic discovery: gravitational waves. How will this affect the theoretical work?
The recent observation of gravitational waves is another extraordinary success of physics. Predicted by Einstein's Theory of General Relativity in 1916, one hundred years later gravitational waves have been observed in an experiment, thanks to remarkable progress in interferometry and to the development of numerical relativity models. This is a repetition of what happened with electromagnetic waves, that were theoretically predicted by Maxwell, roughly in 1865, and then experimentally demonstrated by Hertz some twenty years later. Just as electromagnetic waves radically changed our knowledge and our research tools, we can expect that, in the coming years, gravitational waves will open up new horizons and scenarios, giving rise to real gravitational astronomy. Clearly these developments will have a big impact on our knowledge, perhaps allowing us to understand the quantum structure of space-time and the true nature of gravitational interaction. In short, we expect a very interesting and exciting future! ■