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GALILEO GALILEI INSTITUTE: IN ARCETRI PARTICLE PHYSICS IS THEORETICAL AND INTERNATIONAL

Interview with Stefania De Curtis, director of the Galileo Galilei Institute (GGI), INFN National Centre for Advanced Studies, and research director of the INFN division of Florence.

Since December 2019, Stefania De Curtis has been managing the Galileo Galilei Institute (GGI) in Florence, an institute of excellence for training and research in theoretical physics, founded in 2006. Starting from 2018, the GGI is an INFN National Centre for Advanced Studies, in partnership with the University of Florence.

GGI is located on the hill of Arcetri, a site of historical value for physics and astronomy and where Galilei spent the latter years of his life. Here, each year, over five hundred scientists from all over the world participate in conferences, advanced workshops for the theoretical physics of fundamental interactions and PhD schools dedicated to string and field theory, theoretical elementary particle physics, theoretical nuclear physics, statistical mechanics, astroparticle physics, and cosmology. This is a context of the highest scientific level, characterized by a rare concentration of multiculturalism and excellent ideas.

In 2018, GGI and INFN established the Galileo Galilei Medal, that this year was awarded to Alessandra Buonanno, Thibault Damour and Frans Pretorius. This year award connects Germany, France and the United States, without forgetting the merits of Italy.

We asked Stefania De Curtis to tell us about her career as a scientist and to outline the results and her vision for the future, after her first year as director of the first European institute dedicated to theoretical physics.

The GGI was founded in 2006 with the idea of continuing and encouraging the tradition that has characterised the history of the Hill of Arcetri. When did your personal story intertwine with that of GGI?

From its foundation. In 2004, Giuseppe Marchesini, President of the INFN Theoretical Physics Scientific Committee, promoted the foundation of an international research institute in Arcetri dedicated to the organisation of 2-3 months programmes on “hot” topics in theoretical physics, involving the world’s leading experts in the field. At that time, I was coordinator of the theoretical group of the INFN Florence

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division and fully involved in the foundation of the GGI.
Going back through the previous history, however, my involvement somewhat precedes this date. The foundation of the Galileo Galilei Institute owes much to the intention of a group of Florentine theoretical physicists to keep the "spirit of Arcetri" alive, which is linked above all to the historical value of the place: here, Galileo Galilei spent the latter years of his life in exile and Enrico Fermi wrote one of his fundamental works. Subsequently, in the '60s, Raffaele Raoul Gatto attracted many young theoretical physicists from Rome to Arcetri, who played a major role in the development of modern physics and organised a school of theoretical physics in Florence that has remained a benchmark. Gatto was one of my teachers and collaborators and I have no difficulty in imagining the atmosphere at Arcetri in that very fertile period, which led to the proposal to recreate the same conditions.
Since the first workshop in May 2006, more than 40 other workshops have been organised, with an ever-increasing number of participants. There's another activity, added to workshops, that is the foundation of GGI's prestige today. With its 5 PhD schools – which I have helped to organise and coordinate since their inception – GGI has become an international benchmark in the training of PhD students in theoretical physics. The GGI schools have the distinction of fostering discussion and interaction between professors and students. It is not uncommon at GGI for a world-renowned scientist to discuss unsolved physics problems and, why not, the best trattoria for a "fiorentina (steak)" with PhD students. Not to be underestimated is also the interaction between the students who, in close contact for 2-3 weeks, have a unique opportunity to share ideas and experiences. More than 250 young people attend GGI schools every year, demonstrating the high level of education provided.

For nearly fifteen years, every year GGI has hosted hundreds of scientists, whether researchers or PhD students, from all over the world. How do you manage a centre of this multicultural level and excellence? What goals did you set for yourself when you took office a year ago?
When I took over as director in 2019, GGI was already a Centre of absolute excellence. The task of maintaining such a high standard is certainly one of great responsibility. I felt it was essential to mantain continuity with the previous director and with those who had laid the foundation for the success we had achieved. Among the aspects I would like to develop, I plan to promote and develop outreach activities in order to make our activities and method and the role of our research known outside the theoretical physics community. The goals include not only disseminating knowledge, but above all arousing curiosity towards the biggest mysteries of our Universe, from quantum mechanics to cosmology, and promoting the idea that the technology of tomorrow is developed from the advances in theoretical physics and basic research of today.

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Unfortunately, after only three months as director, we were faced with the lockdown due to the COVID-19 pandemic and the subsequent mobility restrictions. We have had to reschedule some of our activities and run others, such as schools, in a new way. We nevertheless tried to remain a reference point for our community, especially for the community of young researchers. With this objective in mind, we organised "Cortona Young" and "Avogadro Meeting" in which young researchers were able to present their results to an international audience, taking advantage of the prominence of GGI. We also created a series of pedagogical discussion groups on cutting-edge topics in theoretical physics, the "GGI Tea Breaks," and established new postdoctoral fellowships for new PhDs in theoretical physics (the "Boost" Program) in order to complement their training and receive new research ideas in such a challenging environment as that of GGI.

Since 2018, GGI has been promoted to INFN National Centre for Advanced Studies. What does this change in identity entail and how do you envision the institute developing in the years ahead?

On the occasion of the tenth anniversary of GGI, Fernando Ferroni, at the time President of INFN, announced the "promotion" of the GGI to an INFN National Center for Advanced Studies. This represented an important recognition and gave greater prestige to GGI, giving it a clear position within the INFN structures. I wouldn't say it was a change in identity but rather an official recognition of GGI's role in higher education. This status strengthens the already important link between GGI and the INFN Theoretical Physics Scientific Committee, whose president is Chair of the Scientific Committee that selects the research programs to be funded every year.

In addition, GGI's status as an INFN Center helps in coordination with other similar international institutes. This is essential in order to propose impactful activities while maintaining our specificity. Certainly, the COVID emergency has changed the way we develop research programmes: we have been forced to discuss online and have learned how to do so! While interaction in front of a whiteboard is irreplaceable, I foresee a greater need for collaboration across research centres in order to better coordinate the proposal of research programmes.

Finally, together with the foundation of the GGI Center, the Galileo Galilei Medal was established. A prestigious award that this year went to three great scientists, Alessandra Buonanno, Thibault Damour and Frans Pretorius for their studies which, in a complementary way, have led to theoretical predictions confirmed by gravitational wave observations. This represents an outstanding contribution to research and a fundamental one for the birth of a new era, that of gravitational astronomy. I am sure it will give further prestige to the Galileo Galilei Medal.

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Your professional training also inevitably embraces the experimental aspects of particle physics. You have spent much time at CERN since the beginning of your career, at the historic stage when the LHC accelerator was being built. Why did you choose to work on theoretical physics?

There are still so many open problems, for which the existing "theory" has not yet answers.

After many years of research, the Higgs boson was detected at CERN's Large Hadron Collider, confirming the success of the Standard Model, but there is a common consensus that this is not the end of the story. In fact, there are many questions that are not answered within this formulation. The mass hierarchy of particles, to name one. In the Standard Model this is accomplished through numerical adjustments of parameters and is not predicted by the dynamics of the theory. The same is true for the mass of the Higgs boson. The search for an extension of the Standard Model that answers some of the open problems is one of the interests of my research activity. Obviously, this involves comparison with experimental data. For example, if the particle discovered in 2012 at the LHC had different properties compared to the Standard Model Higgs boson, an accurate measurement of them could confirm or rule out some of the proposed models.

Collaboration with experimental groups is therefore very important, so I periodically visit CERN and participate in working groups on physics beyond the Standard Model.

I started visiting CERN when I was a guest of Raoul Gatto at the University of Geneva. We were among the first to study possible signs of new physics at the LHC, which was still in the design phase. Those years were truly inspiring.

Now, with the discovery of gravitational waves, a new phase has opened up. It is possible that the Higgs field was formed as a result of a phase transition in the first moments of the evolution of the Universe. Depending on the nature of this transition, there could be a generation of gravitational waves that carry a complementary "message" to the collider experiments. This synergy paves the way for new developments in the knowledge of the structure of fundamental interactions.

11 February was the International Day of Women and Girls in Science. Reviewing the career that has led you to a management position, what would you recommend to a female student interested in a scientific career or a young female researcher at the beginning of her career?

Throughout my career, I have met great teachers and many collaborators with whom I have shared the joys and sorrows of this profession. The happiness for an accomplishment and the pains, the frustrations, for a calculation that doesn't add up or, even worse, for not even knowing how to set it up. Collaboration, discussion, and exchange of opinions is vital for research. But collaboration, discussion, and exchange of opinions are not always easy to establish by a female researcher when almost all of the collaborators

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are men. To navigate in a male environment, it is necessary to know the laws that regulate it, and to try to take advantage of the few spaces left free. It is undeniably very difficult, but not impossible.
What would I recommend to a female researcher at the beginning of her career? Certainly, to dedicate herself to what interests her most, and to believe in her abilities. Not to attribute the difficulties encountered along the way to an inadequacy in the subject. Her male colleagues never do that! The laws of the male environment can only be less dominant if there are more women in the same environment.

Stefania De Curtis is the director of the Galileo Galilei Institute (GGI) in Florence, since December 2019. She is research director in theoretical physics at the INFN division of Florence. After her degree in Physics from the University of Florence and a PhD from SISSA in Trieste, she was a guest of Raoul Gatto and his group at the Physics Department of the University of Geneva. Since 1988, she has been a researcher at the INFN division in Florence, though she spends several work periods at the University of Geneva and CERN, where she carries out research in the physics of fundamental interactions field. Since 2005, she has been coordinating the corresponding theoretical group of the Florence division. She contributed to the foundation of GGI, of which she has been coordinating the PhD schools since 2013. She is a member of the organising committee of the GGI Lectures on the Theory of Fundamental Interactions and of the Plenary European Committee for Future Accelerators (ECFA). She is the author of more than 100 papers published in international journals and of approximately 60 contributions to conferences and workshops. ■