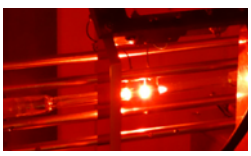
JULY 2021

INFN NEWSLETTER 84

Istituto Nazionale di Fisica Nucleare



INFN _ COMMUNICATION OFFICE

» INTERVIEW

COLLISIONI.INFN: INFN NEW INTERCULTURAL WEB SPACE DEDICATED TO THE PUBLIC AND SCHOOLS

Interview with Antonio Zoccoli, president of INFN and professor of experimental physics at the University of Bologna

Launched at the beginning of July 2021, Collisioni.infn – Spazi culturali all'Istituto Nazionale di Fisica Nucleare (Cultural Spaces at the Italian Institute for Nuclear Physics) is the new INFN web space dedicated to encounters with the public and to the dialogue between physics, other sciences, and all the other expressions of arts and culture. Organised in thematic sections aimed at the public, schools, cultural institutions and other research bodies, Collisioni.infn daily proposes new initiatives for public engagement created and organised by INFN: shows, events, and participation in festivals and exhibition spaces, exhibits and installations, projects dedicated to schools, interactive initiatives devised for social media. Full of links to video and multimedia resources developed for the public by INFN, Collisioni.infn is also a chance for individual learning and keeping up-to-date. Thus, it is particularly useful for students and teachers, as well as for the interested public of any age. An editorial section opens the site, a window that connects the different languages used for developing the projects: initiatives that INFN creates in collaboration with artists and in dialogue with the humanities disciplines and other scientific fields.

We propose here the interview that inaugurates the editorial section of Collisioni.infn, "Incontri" (meetings), dedicated to the dialogue with leaders in the cultural, scientific and intercultural landscape. In the interview, the INFN president Antonio Zoccoli outlines the objectives, values, and expectations connected to this new communication project.

What are the goals of a basic physics research body when it promotes initiatives dedicated to interculturality?

In the current historical moment, whose complexity is sharpened by the pandemic, it's more important than ever to bring knowledge, not only science, to the centre of social life. It is essential that the

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centrality of all the sources of knowledge is restored. In this context, the new INFN web space has the objective of offering the public, of any age or education, a knowledge portal dedicated to the dialogue between science and other cultures. As a research community, we have acquired a vast heritage of specialist scientific knowledge, which has, however, implications in many other sectors of the creative and intellectual sphere. From the most immediate, like the technological field, to the more unexpected, like arts, philosophy and humanities.
The hope is that this web space contributes to raising awareness in society: an occasion for entering into contact and getting to know not only scientific research and its methods, but also its interconnections with other spheres of knowledge. In general, I hope that it can contribute to facilitating the access to knowledge. Particular attention will be dedicated to communication with young people. We pursue this goal, first, because the younger generations will shape the future and, secondly, because we hope that our passion for research may breakthrough and that some young people may want to undertake this journey with us.

What meaning do you give to the word "knowledge"?
Knowledge is the result of our curiosity in what surrounds us and is, at the same time, the tool for further investigating the impacts of reality and its complexity. In this sense, knowledge has a profoundly unitary character, although it is divided according to different facets.
The different fields in which we are used to classify knowledge are strongly connected and interdependent. Because of this, over history, the evolution of philosophical thought, of arts, and of science always went hand-in-hand. Separating them is, more than anything else, an artifice due to the fact that we all struggle, some more and some less, to embrace the vastness of knowledge in order to fully grasp its unity. In any case, it's always worth seeing connections emerge between the different forms of knowing, not only for the pleasure of fuller knowledge, but also because widening our perspective and leaving our own cultural sphere facilitates creativity and ingenuity, including in one's own field.

What prevents sharing knowledge with the public today?
Contemporary ways of living have their roots in scientific and technological knowledge. The wellbeing that we enjoy is owed, above all, to the achievements of science in all fields and to developments in technologies that have radically changed our habits and continue to do so at increasing speed. Despite this, many people tend to distrust science, and even technology, although they depend on it. It is a paradox. One way to counteract this tension with regards to antiscientific thought is to ensure that the positive impacts of pursuing science return to the fore. These include the social benefits of the

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achievements of science, but also the efficacy of the scientific approach for interpreting the reality in which we live and the way in which we relate to it.
A good relationship with science, its method and its language is the first step towards the freedom that follows from knowing how to make informed choices.

What is the role of scientists in public science communication?
As an expert in the research profession and its topics, the scientist is the most suitable and most authoritative person for establishing a direct dialogue with the public on scientific issues. I don't want to dismiss the essential role of mediators, science communicators and those who popularise the subject, professionals in the planning of tools, in the innovation of language and dialogue with the media. However, scientists are always the most credible direct narrators: they have a profound knowledge of the content and can convey, as direct experience, the passion that they experience in doing the research in which they're a major players. This doesn't mean that every scientist is necessarily able to establish a communication channel with the public or that it doesn't require a certain amount of work. We must develop the right, simple, concise language, in compliance with the rigour that science requires, but we must also know how to convey emotions and passion for doing research.
The scientific community counts charismatic scientists among us, able to communicate by nature, and others who will probably have to make some extra effort. Some, unfortunately, erroneously believe that the task of the scientist is exclusively that of doing research and that communicating their work and its results is a waste of time. On the contrary, communicating is an indispensable mission, a duty in relation to society. Without considering the personal benefit. Finding the way to describe something complex, as many ideas in physics are, always enables you to see your own knowledge from a different perspective and to grasp aspects of it that you would have perhaps never seen.

If you had to express a wish, even an ambitious one, to entrust to this online space and to other science communication initiatives what would it be?
That, in the near future, children look at the scientist with the same admiration that they nurture for soccer players, singesr, or actors. The scientific community, institutions and schools, as well as families, must reflect on the fact that most children's ambitions in science aren't comparable with their ambitions in soccer or the entertainment business.
The package of values that we adults transmit, in the different ways, is certainly responsible. We should stimulate scientific curiosity and the desire to learn through research. Although it's difficult, scientific training almost always guarantees a long-lasting and dynamic career, and not just in research. If this idea isn't shared

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by young people, the responsibility probably resides in the way in which we talk about science to children, at school and in the family, and in the lack of a dedicated and effective TV offering, as well as on new media and online.

From 1 June, you assumed the role of President of the Council of Presidents of Public Research Bodies. What role can the council have in the challenge for reviving the value of knowledge?

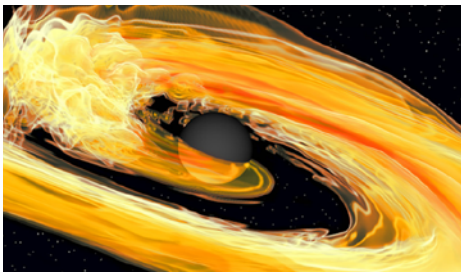
The Council of Presidents of Public Research Bodies [CONPER – ed.] has a strategic role, at the national level. It has the task of supporting the government in promoting, supporting, and relaunching activities in the research sector and of formulating proposals for drafting, implementing, and updating the National Research Programme. The responsibility of this role is even more urgently felt now that we have a very significant challenge in front of us. At a strategic level, the National Recovery and Resilience Plan is a unique opportunity for the relaunch of our country and research, which must do its part, with commitment and seriousness, creating synergies for ensuring that the resources that will be invested produce the best results.

The Presidents of the public research bodies have, on the other hand, a very important responsibility, including at a cultural level. The chance to establish increasing public awareness with regards to science is in their hands and in that of the institutions that they represent, as well as in the hands of schools and universities. In general, the value collectively attributed to culture and to scientific thought is the responsibility of those who design and implement the strategies for scientific research, in all fields of science. ■

RESEARCH INFRASTRUCTURE

EINSTEIN TELESCOPE AND EUPRAXIA INCLUDED IN THE ESFRI ROADMAP

ET Einstein Telescope and EuPRAXIA: two large research facilities that are globally competitive in gravitational wave research and the development of future plasma particle accelerators respectively. These are the two international projects of which INFN is among the leaders, approved by the ESFRI (European Strategy Forum on Research Infrastructures) Assembly and, therefore, included in the 2021 Roadmap of the large research infrastructure that Europe will focus on in the near future. Their candidature had been submitted through MUR (the Italian Ministry of Education, Universities and Research) last September and their approval arrives after a long and careful assessment process. The inclusion of ET and EuPRAXIA in the ESFRI Roadmap is an important recognition that reinforces their strategic value at a European level. Italy has applied to host ET, in an ex-mine in Sardinia, while the main headquarters for EuPRAXIA will be at the INFN Frascati National Laboratories. ■

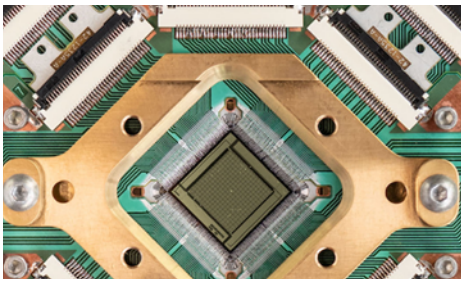


INTERNATIONAL COLLABORATIONS

VIRGO AND LIGO OBSERVE THE FIRST MERGERS OF BLACK HOLES AND NEUTRON STARS

On 29 June, the scientific collaborations of LIGO, KAGRA and VIRGO, which the INFN is part of, announced the first detection of two gravitational wave events produced by the merger of two mixed binary systems composed of a black hole and a neutron star. The results, published in the journal The Astrophysical Journal Letters confirms the existence of a class of phenomena that was already predicted by astrophysicists several decades ago. Until today, however, they had never been observed. These results also open the window onto physics mechanisms responsible for the coupling and successive merger of black holes and neutron stars. The interferometers Advanced LIGO, in the United States, and Advanced Virgo, in Italy, detected the two events. In both cases, the form of the signal recorded made it possible to attribute it to the coalescence of a black hole and a neutron star, the result of which was the creation of an extremely compact body.

Thanks to the study of the two signals, called GW200105 and GW200115, respectively observed on 5 and 15 January 2020, it was possible to establish the masses of the primary sources and the distance of the latter from our planet. In the case of GW200105, an event that resulted from a merger that happened 900 million years ago, the masses of the black hole and the neutron star were estimated to be approximately 8.9 and 1.9 times that of our sun, respectively. For the second signal, characterised by a greater statistical significance than that of the previous one, the black hole was estimated to have a mass of 5.7 solar masses and the neutron star 1.5, with a temporal collocation of the merger at approximately one billion years ago. ■



APPLIED RESEARCH

INFN AND AMAZON WEB SERVICES WORK TOGETHER TO ACCELERATE RESEARCH INTO QUANTUM COMPUTING

INFN and Amazon Web Services (AWS) launched a collaboration aimed at strengthening scientific knowledge of quantum computing, within the Italian research community, and identifying potential applications in high-energy physics and fundamental physics. In the context of this collaboration, AWS will provide the INFN scientific community with access to Amazon Braket's computer resources.

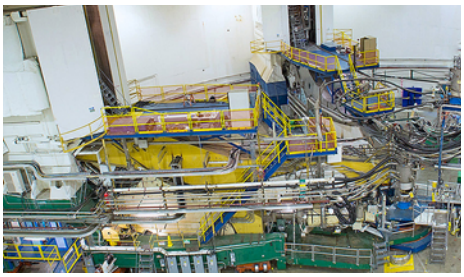
INFN is increasingly engaged in the field of quantum technologies and in high-performance computing. It is the sole non-U.S. partner of the Superconducting Quantum Materials and Systems Center (SQMS) project, funded by the American Department of Energy, and is one of the partners of the EXANEST consortium for developing exascale supercomputers, with a view to the future convergence of high-performance computing and quantum computing. The collaboration with the AWS Quantum Technologies group will contribute, therefore, to strengthening INFN activities in this new research and development field. The INFN researchers will, in fact, have access to different types of quantum computers: from computers that are based on superconducting qubits developed by Rigetti, to computers that use ion traps. This collaboration is, therefore, a new and important element of INFN global strategy in researching quantum computing. ■

APPLIED RESEARCH

IMPACT OF NATURAL RADIOACTIVITY ON QUANTUM COMPUTERS

On 16 June, the journal Nature published a study that looks at the impact of natural radioactivity on the operation of quantum computers. It highlights how gamma particles and cosmic muons can interfere with the complex mechanisms behind the operation of qubits, the constituent elements of quantum computers. Researchers of INFN Rome 1 Division collaborated in the research, which was conducted at the University of Wisconsin-Madison and together with other American and French institutions.

Qubits, an abbreviation of “quantum bit”, can simultaneously save and process data in parallel making quantum computers faster and more powerful than conventional computers. In any case, by studying the performance of a matrix of qubits for several hours, the scientists observed that, in many cases, several qubits were simultaneously affected by memory errors: a crucial problem for developing a quantum computer. The protocols to correct memory errors predict, in fact, that if a qubit fails, the others can store information, thus making it recoverable. But if several errors occur simultaneously, the information is permanently lost. Using simulations developed by the INFN team, which reproduced the effect of the interaction of natural radiation particles with the superconducting circuits, it was possible to demonstrate that these simultaneous errors occurred due to natural radioactivity. This represents an innovative contribution to the research into qubit operation that will make it possible to expand the research conducted until now and to better understand the effects of natural radioactivity on qubit operation. ■



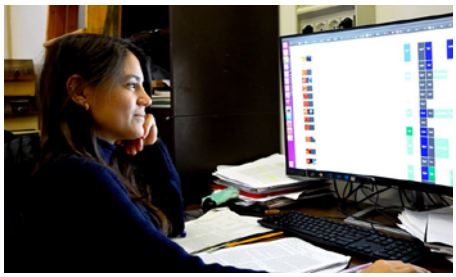
RESEARCH

THE E-97-110 EXPERIMENT MEASURES UNEXPECTED BEHAVIOURS IN NEUTRON CONSTITUENTS

A study published on 31 May in the journal Nature by the E-97-110 collaboration, an experiment housed at the Jefferson Laboratory in Newport News, Virginia, which involves an important INFN contribution, highlighted the anomalous behaviour of the constituents of neutrons under the action of a magnetic field. The anomaly refers to the way in which neutron quarks and gluons reorganise themselves following a change in the orientation of the particle's spin, owing to the magnetic field. The behaviour differs from that expected by non-perturbative quantum chromodynamics (QCD), the relevant theory for describing the interactions between quarks and gluons on the scale of nucleons, protons, and neutrons.

The E-97-110 experiment uses polarised electrons, or those with a spin oriented in a precise direction, produced by the Jefferson Lab's CEBAF accelerator, which are made to collide with a target of neutrons, which are also polarised. The task of studying the particles produced following the collision is entrusted to two large spectrometers.

The measurements made by E-97-110 demonstrate the lack, in the current state, of a realistic quantitative description of the strong interaction, the force responsible for the bond between the quarks inside the nucleons, on the spatial scale of these particles. ■



AWARDS

ORNELLA JULIANA PICCINNI WON THE 2021 L'ORÉAL-UNESCO "FOR WOMEN AND SCIENCE" AWARD

Ornella Juliana Piccinni, researcher with INFN Rome 1 Division at the Amaldi Research Center of the Sapienza University of Rome, and a member of the Virgo collaboration, is one of six winners of the 2021 L'Oréal-Unesco "For Women and Science" award. This is a benchmark annual event for raising public awareness on the essential role women perform in scientific research. Ornella Juliana Piccinni was awarded a scholarship worth 20,000 Euro, during an online event on 17 June, thanks to a project dedicated to modelling and identifying gravitational signals produced by magnetars (neutron stars with an extremely intense magnetic field). The project is dedicated to developing a specific line of analysis for studying signals emitted by magnetars, young neutron stars that are distinguished by a high rotation and an extreme magnetic field. Instituted in 2002 by the French cosmetics company L'Oréal, in collaboration with the Italian National Commission for UNESCO, the prize "For Women and Science" assigns an equal amount of funding to 6 scientists under 35 who are active in the fields of Life and Materials Sciences. The purpose is to encourage and support their research work and professional growth in Italian universities or research centres. The jury in charge of selecting projects submitted by candidates has been headed by Lucia Votano, INFN research director, since 2017. ■

AWARDS

SIF 2021 "ENRICO FERMI" PRIZE GOES TO ELENA APRILE AND PATRIZIA CARAVEO

The 2021 "Enrico Fermi" prize of the Italian Physical Society (SIF) was awarded ex-aequo to researchers Elena Aprile and Patrizia Caraveo, "for their remarkable contributions to the study of the Universe with different observables and techniques".

More specifically, Elena Aprile, Professor at Columbia University of New York, was awarded the prize "for her pioneering research on the properties of liquid xenon for radiation detection and her contribution to search for dark matter", having proved essential to the construction of the XENON experiment at the INFN Gran Sasso National Laboratories. While Patrizia Caraveo, research director at the Institute of Space Astrophysics and Cosmic Physics at the Italian National Institute for Astrophysics in Milan, received the award "for being a world leader for high energy emission from neutron stars and for her contribution to the identification of Geminga". ■

PUBLIC ENGAGEMENT

BEAMLINE FOR SCHOOLS: BARI STUDENTS WIN INTERNATIONAL CERN COMPETITION

EXTRA, the team of 13 students from the science-oriented high school “A. Scacchi” in Bari, together with a team from Mexico City, won the 2021 edition of “Beamline for schools” (BL4S), the international competition aimed at high schools organised by CERN.

The Bari team was awarded victory, competing against 289 teams from 57 countries throughout the world and presenting a scientific project for studying “transition radiation”. Their project was developed in collaboration with researchers from the Bari division of the Italian Institute for Nuclear Physics and with the Interuniversity Physics Department of the University and Polytechnic University of Bari. As a prize, the students from the two winning teams will spend two weeks in September at the German DESY research centre in Hamburg to carry out their experiment.

It is the third time in eight years that an Italian team was awarded victory. This year, 12 of the 289 teams that participated were Italian and, in addition to the winning team, the “Copernical Particles” of the “Niccolò Copernico” high school in Bologna reached the finals, while the “Leonardo’s Players” team of the “Leonardo da Vinci” high school in Fiumicino received recognition for the quality of their work. ■

TAKE PART IN

12-15 JULY, INFN KIDS SUMMER CAMP "SUMMER WAVES - STORIES ABOUT SOUNDS, LIGHT, AND FANTASTIC PARTICLES"

The Summer Camp returns on the website, Facebook page, and YouTube channel of the INFN Kids project. The Camp is dedicated to the littlest ones, to bring them, with stories and experiments, to the amazing world of sound, electromagnetic, and gravitational waves. For more information

16 JULY, AT 8:00 P.M.,TEDXMACERATA: LEAPS IN KNOWLEDGE (URBISAGLIA, MC)

Roman Amphitheater of the Archaeological Park of Urbs Salvia
Antonio Zoccoli, INFN president, will participate. For more information and booking.

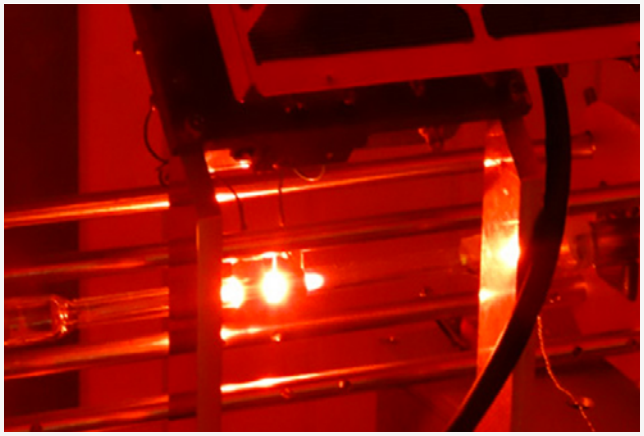
17 JULY, INFN AT "FOSFORO: THE SCIENCE PARTY" (SENIGALLIA, AN)

AT 7:30 p.m., Casa San Benedetto: WHERE THE UNIVERSE IS GOING
Scientific aperitif with Fernando Ferroni, INFN researcher and professor at the GSSI [Gran Sasso Science Institute].
AT 9:30 p.m., Piazza Garibaldi: PARTICLE PHYSICS: FROM GRANDMOM'S TELEVISION TO LHC
Science show with Valentina Mariani, researcher with the INFN Perugia Division, and Alessandro Gnucci, Fosforo science festival. For more information and booking

17 JULY, INFN AT THE RIMINI WEB MARKETING FAIR (RIMINI, RN AND ONLINE)

At the *Research for Future* open stage, during the fair dedicated to digital innovation, two addresses on frontier research themes for INFN. For more information and booking.
AT 08:50 a.m.: INFN PROGRAMMES FOR LIFE SCIENCES
With Giacomo Cuttone, INFN - Southern National Laboratories researcher
AT 12.45 a.m.: EINSTEIN TELESCOPE: A LATEST-GENERATION, GRAVITATIONAL WAVE OBSERVATORY
With Alessandro Cardini, INFN and University of Cagliari researcher

» FOCUS



GINGERINO MEASURES THE EARTH'S ROTATION SPEED AND GRAVITATION FIELD

You can precisely measure the rotation speed of the Earth by comparing light signals that propagate with opposite trajectories. An article that appeared on 8 May on the *Springer European Physical Journal C* supports this argument, publishing the results relating to the last analysis conducted by GINGERINO, a ring laser gyroscope housed at the INFN Gran Sasso National Laboratories. The study highlighted the ability of the equipment to provide, with accuracy beyond expectations, values of the Earth's angular speed that agree with those obtained from sophisticated satellite systems and astronomical interferometry, which are today used to monitor the parameters linked to our planet's rotation. The experiment is one of the GINGER (Gyroscopes IN GEneral Relativity) group of activities. GINGER is a scientific collaboration between Italian research bodies led by INFN, which aims to demonstrate the efficacy of devices like GINGERINO in the field of testing General Relativity.

GINGERINO is basically a ring laser, characterised by an optical resonator, consisting of four mirrors positioned at the corners of a square. The cavity is filled with a mixture of helium-neon gas that is excited by a radiofrequency discharge, thus generating two counter-rotating laser beams. In the absence of rotation, the two optical paths are identical and the photons use the same time to close the ring, but that is not true if the cavity is rotating. In this case, the two opposing laser beams will have different frequencies: the difference can be detected by recording the superposed interferometric signal, which is proportional to the rotation speed. This phenomenon is known as the Sagnac effect. Thanks to GINGERINO's symmetrical structure, many of the typical noises of standard interferometry are strongly mitigated, making it possible to precisely measure phenomena described by General Relativity as well.

The use of the Sagnac interferometers was, until today, limited due to the difficulties of analysing the data produced. This analysis must take into account the complex dynamics of the laser that generates the two counter-rotating beams inside the cavity and of the noise produced by the action of external

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forces. This is why the GINGER collaboration researchers decided to use a technological demonstrator: GINGERINO, and to anchor it to the rock of the Gran Sasso National Laboratories. Here, it is sheltered from atmospheric agents so researchers can study solutions aimed at creating a future interferometer with greater sensitivity and to improve its ability to discriminate between data acquired.

The researchers compared data obtained by the experiment over the course of 103 days' operation with those acquired by the proven and accurate systems of triangulating radio signals coming from satellites or from astronomical sources. The latter signals are used to determine the rotation speed of our planet and of Coordinated Universal Time (UTC) - the standard time on the basis of which we adjust our watches - as well as other geodesic parameters, such as the shifting of the poles and the change in the tilt of the Earth's axis. This comparison has highlighted a substantial correspondence between the measurements and an unexpected sensitivity on the part of GINGERINO, equal to fractions of femtoradians (10^{-15} radians) per second, quantities corresponding to the subatomic scale. If confirmed, the result would guarantee the actual ability of the Sagnac interferometers to distinguish between different theories of gravitation and to highlight, in the final analysis, effects capable of reconciling gravitational interaction with quantum mechanics.

Finally, the latest-generation equipment, like GINGERINO, could provide a valid, alternative tool in studying phenomena that influence the rotation of our planet, changes to the tilt of the Earth's axis, and geological features of the areas in which the interferometers are installed.

The GINGER collaboration is led by INFN with the contribution of INGV Italian National Institute for Geophysics and Volcanology. Through the Legnaro and Gran Sasso National Laboratories, the Pisa, Naples, and Turin Divisions, INFN was responsible for the planning and implementation of GINGERINO and is in charge of the data analysis acquisition activities. ■

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