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Istituto Nazionale di Fisica Nucleare

INTERVIEW

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THE AMALDI PLAN FOR THE RELAUNCH OF ITALIAN SCIENTIFIC RESEARCH

Interview with the physicist Ugo Amaldi, founder of the National Centre for Oncological Hadrontherapy (CNAO) in Pavia and the proposer of the Amaldi Plan for Italian research.

To increase the percentage of Italian Gross Domestic Product (GDP) allocated to financing both basic and applied public research, starting from 2021, in order to be aligned with Germany's investments in the same sector, equal to almost 1% of German GDP, in 2026. This, in a nutshell, is the request sustained also by a petition launched on the Change.org platform, addressed to the Italian Prime Minister Giuseppe Conte and started from considerations expressed by the physicist Ugo Amaldi. A proposal that must adopt meritocratic criteria for distribution of investments in the four areas considered crucial for research: human resources, projects, infrastructure and technology transfer; and which, thanks to the spin-offs generated, would guarantee greater competitiveness and economic growth in our country. The key points for the relaunch of Italian research, which has already received the support of notable members of the Italian scientific world, are based on an articulated program presented in June of this year by Ugo Amaldi, an internationally renowned physicist and founder of the National Centre for Oncological Hadrontherapy (CNAO) in Pavia, who has always been an influential voice in support of more incisive research policies aimed at developing the great wealth of scientific expertise in our country. Starting from the proven ability of basic research to promote the development and transfer of new technologies, the Amaldi Plan, as it is now called, identifies the increase in public funds to this sector as an effective method for increasing the competitiveness of the Italian industry, whose expenditure in research and development activities remains far below that of Northern European countries. An investment which, in the light of the recognised value of our researchers, among the most productive in the world, would be certain and profitable.*

How and in which context did your proposal come about?

At the invitation of Giuliano Amato, President of the Cortile dei Gentili scientific committee, in March, I joined a group of intellectuals called to discuss the evolution of the most pressing current issues. An initiative that subsequently led to the drafting of a short text in which we illustrated what we felt should be the

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development guidelines to be pursued in Italy and our suggestions for politics and citizens. In this context, I went back to explore a topic I had already focused on in 2008, namely the quality of Italian research. The result of this work was the drafting of the fifth of the six proposals contained in the introductory part of the book "Pandemic and resilience" later published: the fifth proposal is presented in detail in the book itself. More recently, the proposal was adopted by Federico Ronchetti, who had the merit of launching the issue on social media and then a petition, and by Luciano Maiani, who became the spokesman of the plan that emerged from it with Minister of University and Research Gaetano Manfredi.

What are the main points of your plan to relaunch Italian research?

The essence is to double public investment in basic research by taking advantage of the funds provided by the Next Generation EU growth programme, with the aim of achieving Germany's performance. In order to achieve this, I propose a gradual approach that involves allocating 1.5 billion euros immediately and increasing investment, both national and European, to the level of French investment within the next three years, and then being able to do a little better than Germany after another three years. This would mean allocating 0.8% of GDP over the first three years and 1.1% of GDP at the end of a six-year period. In addition to the lack of Italian Government's actions in favour of research, my proposal for public intervention is also motivated by the fact that our country's industries are lagging behind in investment in research and development, which stands at just 0.9% of GDP, compared with 2.1% in Germany, a figure that would have been even smaller without the contributions of state-owned companies. What we need to do, therefore, is to try to do better than Germany, to try to make up for the missing contribution form industry.

Why do you think it is appropriate to invest in basic research?

Despite the limited resources, the trend in total citations of scientific research worldwide shows that Italy, from 2010 to 2015, improved its performance by 20%, while France and Germany recorded a 25% decrease over the same period. We therefore have a productivity per researcher that is no less than that of other countries. An aspect that makes it advantageous to invest in Italy already today, without the need for reforms, because this would result in an assured production of new knowledge, despite insufficient infrastructure and remuneration. A further argument in favour of increasing the funds allocated to research concerns the percentage of female researchers in our country, 47% of the entire community. A much higher number of female scientists than in France and Germany. An investment in this sector would therefore translate into an investment in Italian women engaged in research, who could thus, as they already do, provide their fundamental contribution to scientific enterprise.

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What are the benefits of a possible implementation of your plan?

There are hundreds of studies that have demonstrated the close correlation between increased investment in research and annual GDP growth. In the light of this evidence, if we could increase the efficiency of our technology transfer, a key part of the petition and of my proposal, we would increase the growth rate, achieving important benefits for increasing the economic product of the Italian system. The long-term objective must therefore be to achieve a degree of competitiveness equal to that of France and Germany. Finally, a key advantage that could be derived from the increased availability of resources in science would be the possibility of encouraging young people to embark on an academic career. In fact, we could significantly increase the number of graduates in Italy, among the lowest in the Eurozone, by providing young people with career prospects that are currently lacking.

Do you think that the pandemic has had the merit of refocussing the spotlight on research and the importance of its adequate funding?

Yes I do, which is why I cannot understand the lack of support for the petition. Nevertheless, I believe that awareness of the importance of public research in the life of all citizens is an aspect that is part of the process of increasing scientific literacy that has taken place over the last ten years: Italians have realised that there is a need for scientific skills to solve problems. I therefore believe that, also for this reason, this is an appropriate time to call for a greater effort in financing research.

In your opinion, should the funds that will be allocated with the Recovery Fund be partially allocated also to research?

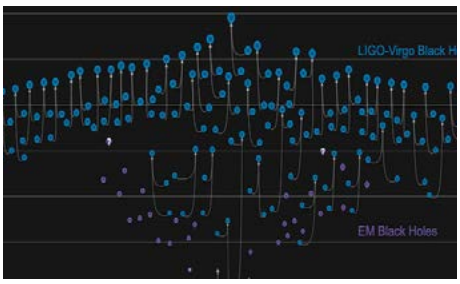
The opportunity to have funds of the Recovery Fund available to rebuild the country is unique and unrepeatable. We are investing billions in school desks to get students safely back to classrooms, a common sense approach which everyone should agree on and that goes in the right direction. But we must also think about the future of these young people who will soon have to enter the world of work, a world which they will be precluded from if Italy does not take the road of development and growth. It is therefore necessary that, despite pressure to direct its attention to other problems in our country, the Government looks towards the new generations, which are the future of Italy. ■

** In Italy, public investments in research and development are equal to 0.5% of GDP, of which 0.32% is spent in basic research and 0.18% in applied research (from "Pandemia e Resilienza", CNR Edizioni)*

TECHNOLOGICAL RESEARCH

EUROPEAN TECHNOLOGY FOR THE NEW LEONARDO SUPERCOMPUTER

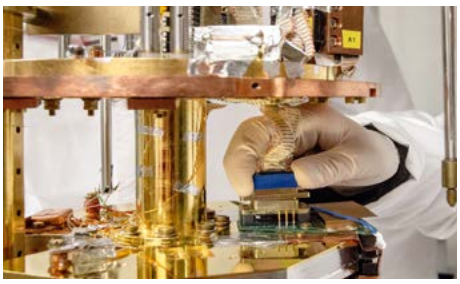
Announced in October, during an online meeting open to the media, the award of the contract for the supply of the technological components of Leonardo, the new high performance supercomputer that will be installed in 2021 at the Tecnopolo in Bologna, to the European company Atos. The computer will be one of the nodes of a European distributed computing network that will take shape in the coming years. The Cineca consortium, in collaboration with INFN and the International School of Advanced Studies (SISSA) and with the support of the Ministry of University and Research (MUR) and the Regione Emilia Romagna, is responsible for the management of Leonardo, as well as being its creator. Leonardo, the construction of which was approved in June of last year by the European High Performance Computing Joint Undertaking, a European body aimed at promoting the development of a network of supercomputers, will be characterised by high performance, being able to perform almost 250 billion operations per second (250 petaFlops). A capacity 10 times greater than the current Marconi100 calculator available to Cineca. The project is part of the first phase of the Euro HPC initiative, which aims to build one of the best performing computing infrastructures in existence through the installation of three pre-exascale class computers in three European cities. In addition to the 120 million allocated by the European Commission, Leonardo will benefit from a further 120 million provided by the MUR. The positive repercussions from exploiting Leonardo's computing capabilities will also provide important benefits in basic research. ■



RESEARCH

OVER 100 BLACK HOLES OBSERVED BY THE LIGO-VIRGO TRIO IN THE FIRST RUN OF 2019

The Ligo-Virgo scientific collaboration has published on ArXiv the *scientific catalogue* that presents the final results of the first run of the last observation campaign, the third (O3a), which began in April and ended in October 2019.
39 gravitational waves events have been captured by the interferometers, for a total of over 100 black holes. Most of them are due to mergers of black holes, whose characteristics, however, pose questions on some established astrophysical models and open new scenarios. During the same period, a probable fusion of neutron stars and two probable mixed systems with neutron stars and black holes were also detected.
The researchers of the Virgo and LIGO collaborations have worked a full year to complete the analysis and study all the gravitational signals recorded by the Virgo interferometer and the two LIGO interferometers, together with the cosmic events that generated them millions or billions of light years from Earth. In detail, the events are 36 fusions of black holes, a probable fusion of a binary system of neutron stars and two systems most likely composed of a black hole and a neutron star. The four most relevant results have already been announced and published during the last year. The catalogue published today presents, for the first time, a complete picture of the extraordinarily high number of recorded gravitational signals and their sources. ■



TECHNOLOGICAL RESEARCH

DART WARS: QUANTUM AMPLIFIERS FOR COMPUTERS OF THE FUTURE

Developing new ultra-sensitive quantum amplifiers capable to improve data and qubit transmission in the computers of the future, including the quantum supercomputer to be built in the U.S. at Fermilab in Chicago. This is the challenge faced by the project "Dart Wars" (Detector Array Readout with Traveling Wave AmplifieRS) to be carried in collaboration by Milano Bicocca University and INFN, thanks to a 1 million euro funding approved by the INFN CSN5's Call "Development of quantum technologies for the physics fields of interest for INFN". The three-years-long project will be developed by the researchers of the Cryogenics Laboratory of the Physics Department "Giuseppe Occhialini" of the Milano Bicocca University. Among the partners, also INRIM (National Institute of Metrological Research) and the Bruno Kessler Foundation of Trento.

The activities that will be developed within "Dart Wars" have strong synergies with the projects led by American SQMS Center (Superconducting Quantum Materials and Systems Center), which sees INFN as the only Italian partner. The U.S. project has recently received funding of $ 115 million from the U.S. Department of Energy, to develop in five years a cutting-edge quantum computer, with performance and computational speed never reached before. ■

AWARDS

2020 NOBEL PRIZE FOR PHYSICS GOES TO BLACK HOLES

A half of the 2020 Nobel Prize for Physics has been awarded to the English physicist Roger Penrose, "for the discovery that black hole formation is a robust prediction of the general theory of relativity", while the other half was awarded jointly to the German physicist Reinhard Genzel and the American physicist Andrea Ghez "for the discovery of a supermassive compact object at the centre of our galaxy". In particular, Roger Penrose demonstrated that the general theory of relativity leads to the formation of black holes, while Reinhard Genzel and Andrea Ghez discovered that an invisible and extremely heavy object governs the orbits of the stars at the centre of our galaxy and a supermassive black hole is the only currently known explanation. "This year's Nobel Prize to Penrose, Genzel and Ghez is a great recognition not only for the three scientists – said INFN President, Antonio Zoccoli - but also of the work of a large community of researchers working on black hole physics, to which INFN provides a fundamental contribution on both the theoretical as well as observational front, participating in large international collaborations such as EHT and managing the VIRGO gravitational wave interferometer which, together with LIGO, has allowed the experimental observation of new black hole populations. We are also working with great commitment on the future of the study of these astrophysical objects, through the study of gravitational waves and designing the new generation Einstein Telescope interferometer for which Italy has nominated Sardinia as the host site". ■

AWARDS

VALENTINA MARIANI HAS WON THE L'ORÉAL FOR WOMEN IN SCIENCE AWARD

Valentina Mariani, a researcher at the INFN division in Perugia and member of the CMS collaboration, is among the winners of the 2020 edition of the "L'Oréal Italia For Women in Science" award. Established eighteen years ago by the French cosmetics company L'Oréal, in collaboration with the Italian National Commission for UNESCO, the programme awards 6 scholarships, each worth 20,000 euros, to 6 female Italian scientists under the age of 35, engaged in life sciences or in the fields of physical sciences, mathematics and computer science, in order to encourage and support their research work and professional growth, while promoting the essential role of women in the scientific enterprise. Valentina Mariani was awarded the funding thanks to a project on the development of the upgrades to the CMS experiment, one of four experiments at the CERN LHC, to be implemented in the near future. The jury of the award, which evaluated more than 300 applications from all over Italy, was chaired by Lucia Votano, INFN Emeritus Research Director. The scholarship will allow the winners to work for ten months in collaboration with L'Oréal at any Italian institute and therefore to carry out their respective research activities. The project coordinated by Valentina Mariani will concern the design of the data analysis for the CMS experiment, related to the LHC high-luminosity phase, which, starting from 2027, will produce a much higher number of collisions between particles inside the accelerator than currently available. This will result in the production of a greater amount of data than in the past, which could provide access to rare phenomena that we are currently unable to observe. ■

PUBLIC ENGAGEMENT

STEM: SELECTION OPENED FOR THE SCIENCE ON STAGE ITALY FESTIVAL

The call for participation in the *Science on Stage Italy Festival*, an event aimed at teachers and dedicated to encouraging the development and identification of new teaching tools for teaching STEM disciplines in schools of all levels, which will take place next year in Faenza from 16 to 18 April, is now open. The event, of which INFN is the main sponsor, will provide a showcase for the 30 best proposals submitted during the current pre-selection phase. 11 of the projects that will be presented in Faenza will also have the opportunity to be chosen to represent Italy during Science on Stage Europe, scheduled for 2022 in Prague, which will bring together the winners of the national editions of the initiative. Supporting Science on Stage Italy, together with INFN, are INAF, the Cagliari Science Festival, the Association for Teaching Physics (AIF), the Italian Chemical Society and the European Association for Astronomical Education. Founded in 2000 as a European network with the aim of promoting the sharing and exchange of ideas and concepts to facilitate the creation of methodologies to improve physics learning, in 2004 Science on Stage Europe became an international and interdisciplinary platform for teachers of all scientific disciplines wishing to learn more effective educational systems. The national activities carried out within the scope of the initiative, which now has 35 member States, including Italy, are presented during a large exhibition that brings together the projects of 450 teachers of STEM subjects, an event that takes place every two years in a different European capital. ■

PUBLIC ENGAGEMENT

DARK MATTER DAY 2020 | IN SEARCH OF DARK MATTER

On Saturday 31 October at 11:00 the international scientific community celebrates Dark Matter Day.
Two events are scheduled for Italy, organized by INFN:
- on Saturday 31 October, at 11.00 a.m CEST, a live dialogue on *Facebook* and *Youtube* with six researchers, all experts on dark matter, and an exceptional guest, the astronaut Luca Parmitano.
- on Friday 30 october, at 3.30 p.m CEST, the *Darkside Masterclasses* aimed at Italian students. ■

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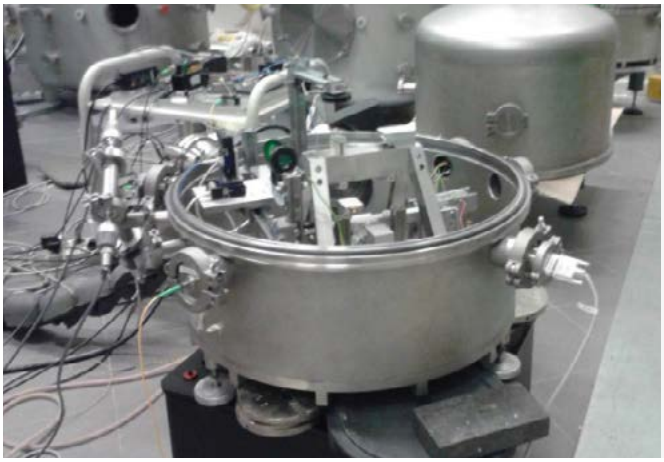

THE WEIGHT OF THE VACUUM: A STEP FORWARD FOR ARCHIMEDES

The 5-tons steel chamber, a fundamental element of the INFN Archimedes experiment, has arrived in Sardinia, the first to be installed in the SARGRAV underground laboratory in Lula, in the province of Nuoro. The scientific objective of Archimedes is to “weigh the vacuum”, i.e. to investigate the role of the interaction of vacuum fluctuations with the force of gravity, in order to help to find an answer to open questions of fundamental physics and cosmology, such as the nature of mysterious dark energy.

In quantum mechanics, Heisenberg's uncertainty principle states that the complete absence of particles and energy in a vacuum is not possible. It must therefore contain “virtual” particles that are dynamically created and then destroyed (annihilated) giving rise to continuous energy fluctuations. If we could measure the interactions between these energy fluctuations, caused by continuous annihilations, and gravity, we could say that we have "weighed the vacuum” and, therefore, created a bridge between vacuum and gravity.

But how does the Archimedes experiment work? The fundamental unit of the experiment is a super-sensitive scale with a 1 metre long arm, which will be built by the researchers of the INFN Naples division working on the experiment. The scale must be able to measure the small weight variations induced in two samples of a material that has the property of “trapping” or “expelling” vacuum energy when its temperature is changed. These two samples that constitute the "plates" of the scale are 10 cm wide and 3 mm thick discs made of a particular type of material that has the property of becoming superconductive below 100 K (-173°C), while above this temperature it behaves like an insulator. This material, called YBCO, is a superconductor and has a microscopic structure consisting of many layers (approximately one million) just a few nanometres apart: it is in the microscopic space between these layers that the so-called Casimir cavities are created, regions where the energy of the vacuum (due to

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the annihilation between particles and antiparticles) becomes lower than outside. For this reason, when it is brought below its critical temperature, YBCO becomes lighter and, by modulating the temperature of the discs around their critical temperature by irradiation, any variations in their weight can be measured and thus the interactions between vacuum fluctuations and gravity can be studied.

To be able to operate this scale at very low temperatures, cryogenics is required. The scale will therefore be installed inside a cryostat, under construction at the INFN Rome 1 division. The cryostat will consist of three steel chambers, the first of which is the 5-tons experimental vacuum chamber that has just arrived in Lula, while the second is a chamber with 4000 litres of liquid nitrogen which, like a matryoshka, will be in a third one, called the isolation chamber, where a vacuum will be created to isolate the system from the outside.

Archimedes will therefore have to carry out very high precision measurements, which is why the experiment will be installed in one of the "quietest" places in Europe: the SARGRAV underground laboratory, inside the former Sos Enattos mine. Here, in fact, seismic noises or sounds of anthropogenic origin and Newtonian noise, due to local variations in the force of gravity, are very low. For this reason, the site has been nominated to host the ambitious international Einstein Telescope (ET) project in which Italy is participating with INFN, the National Institute for Astrophysics (INAF), the Italian Institute for Geophysics and Volcanology (INGV) and the Universities of Sassari and Cagliari. ET will be an underground triangular-shaped interferometer with 10 km long arms, which will use highly enhanced technologies compared to those currently available to study gravitational waves. And, precisely in order to confirm its suitability to host the future ET telescope, Archimedes will also have the task of making very accurate measurements of the background noise of the Sos Enattos site.

Archimedes is an experiment funded by INFN. Together with the INFN divisions of Naples and Rome 1, the experiment also involves the Federico II University of Naples, La Sapienza University of Rome, the University of Sassari, the European Gravitational Observatory (EGO), the CNR National Institute of Optics (CNR-INO) and the Aix-Marseille Université. ■

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