No place like Rome

CMTP Director Professor Roberto Longo talks to *Public Service Review* about the why the Italian capital is a haven of mathematical physics research...

The Center for Mathematics and Theoretical Physics (CMTP) at Tor Vergata University in Rome is marking its first year in existence with a symposium featuring some of the greatest names in pure and applied mathematics in Europe and across the wider world. The centre, founded in November 2009, counts among the members of its Scientific Council distinguished researchers from the Mathematics and Physics Departments of the three Roman universities – La Sapienza, Tor Vergata and Roma Tre.

The aim of the facility is to take advantage of the high quality and wide spectrum of research in mathematical physics presently carried out in Rome in order to promote the cross-fertilization of mathematics and theoretical physics at the highest level, by fostering creative interactions between leading experts from both subjects.

Mathematical physics is a flourishing area of research in Italy, and in Rome especially. In terms of pure research, modern mathematical physics – applied to fundamental mathematical problems of the latest physical theories – occupies what is perhaps, numerically, a minority role. Conceptually however, it is central, furthering a deeper understanding of physical theories through new, rigorous lines of mathematical research.

All major industrialised countries can now count on prestigious centres of pure scientific research that attract the most eminent scientists and promote science at the highest levels. For instance, the IHES in Paris, the Max Planck Institutes in Bonn, the ETH in Zürich, the RIMS in Kyoto, and the IAS in Princeton, can count among their members a number of recipients of the Nobel Prize in Physics and the Fields Medal. The MRSI in Berkeley, the Newton Center in Cambridge, the Schrödinger Institute in Vienna and the Fields Institute in Toronto are pretigious centres too, and there are projects for new big centres in Paris and Madrid.

Italy, and in particular the Roman area, is in a unique position as far as basic scientific interdisciplinary research between mathematics and theoretical physics is concerned, not only because of the high quality of research but also for the ample spectrum of subjects studied. The only way to increase research and scientific culture is to take advantage and further the high competences available in order to catalyse further developments.

The creation of a research facility in mathematics and theoretical physics in Rome was therefore a natural step to provide Italy and the city of Rome with an instrument of international visibility and impact. Here Professor Roberto Longo, Director of the CMTP, explains to *Public Service Review* the inspiration behind the new centre.

How do you intend to involve international scientists and mathematicians?

Sustaining modern research in mathematical physics is central to establishing a strong foundation for the development of fundamental scientific research in Italy. Above all, this support requires incentives for new generations to dedicate themselves to pure science and to mathematical physics in particular. These incentives involve perspectives of work but also visibility and resonance for research activity, the possibility of international exchanges and a continuous stream of visitors who in turn bring experiences and exchanges with the world's most prestigious research groups.

At the opening activity of the Center for Mathematics and Theoretical Physics, in September, we are going to have a symposium entitled 'Seminal Interactions between Mathematics and Physics', with the intention of attracting great international experts to Rome and to give an important stimulus to a large number of young researchers in both fields. The list of speakers includes some of the most active and well-known scientists in mathematics and theoretical physics: Alain Connes, Alessio Figalli, Klaus Fredenhagen, Stefan Hollands, Victor Kac, Yasuyuki Kawahigashi, Joel Lebowitz, Andrea Montanari, Andrei Okounkov, Stanislav Smirnov, Gabriele Veneziano, Cédric Villani, Feng Xu and Lai-Sang Young.

As part of the symposium, we are also going to have two public lectures, held by two scientists well known even to the general public, Ludvig Faddeev and Isadore M. Singer, with the aim of publicising the centre and to inform a larger audience of some recent developments in mathematics and theoretical physics.

What are the main areas of research currently taking place in the field mathematical physics?

Mathematical physics might be defined as the application of mathematics to problems in physics and the development of mathematical methods suitable for such applications and for the formulation of physical theories. In reality mathematical physics is more than that – mathematics is the language of physics and physics is the primary source for mathematics, and indeed in the past the two disciplines were essentially unified. Physical problems have always led to the development of fundamental mathematics. On the other hand, for reasons that we don't know, fundamental mathematical developments sooner or later find applications to physics.

There are several areas of research that can be considered in mathematical physics. The theory of partial differential equations (and the related areas of variational calculus, Fourier analysis and vector analysis) has been commonly associated with mathematical physics for hundreds of years.

Nowadays a fundamental branch of mathematical physics comprises quantum mechanics, operator algebras and, more broadly, functional analysis. The special and general theories of relativity require a rather different type of mathematics, particularly group theory together with topology and differential geometry. Statistical mechanics forms a separate field, which is closely related with the more mathematical ergodic theory and some parts of probability theory. There are also increasing interactions between combinatorics and physics, in particular statistical physics, and there is a striking interaction between string theory and algebraic geometry.

It is internationally recognised that interdisciplinary scientific research between mathematics and physics carried out in Rome is at the top of the international scale. In particular, Rome is unique in the world for the spectrum of subjects studied, such as Statistical Mechanics, Low Temperature Physics, Quantum Field Theory, Complex Systems, Algebraic and Differential Geometry, Operator Algebras and Dynamical Systems.

What advances have Italian schools and higher education sectors made in attracting new pupils to science, technology, engineering and mathematics (STEM) subjects?

There are several measures that the Italian school systems and universities have taken to attract students to scientific subjects. From the purely monetary point of view, for example, in most universities the registration fees are significantly reduced for students registering in scientific disciplines such as mathematics and physics. Moreover, to encourage the brightest students to enrol in mathematics, the Italian Institute of Higher Mathematics (INdAM) gives a number of fellowships each year to students who decide to major in mathematics.

Another important initiative is the so-called 'Progetto Lauree Scientifiche', a project which started a few years ago with the intention of attracting students to the scientific disciplines. More precisely, the project offers a variety of initiatives which try to stimulate the interest of the brightest students to the study of scientific topics, to give a more adequate preparation in the scientific disciplines, and to facilitate the interaction of the university system with the high school system on the one side, and with industries on the other side. Among the activities of the project are, for example, 'laboratories' in various scientific disciplines, including mathematics and physics, organised by university professors in collaboration with high school teachers for the most motivated students, and also courses taught by university professors to high school teachers.

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Among the efforts to attract students to scientific disciplines, and in particular to mathematics and physics, it is worth mentioning the emphasis given to events such as the Olympiads for high school students. In this regard, it is important to note that in recent years the results of the Italian mathematics team have been very encouraging, and in each of the last two editions of the Olympiads (the last took place in Kazakhstan in July of this year), Italy ranked 11th (second in Western Europe after Germany) – our best ever result. It is widely believed that the emphasis given to such events and such encouraging results have a stronger effect than any financial incentive in attracting the brightest students to study mathematics and, more generally, scientific disciplines.

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