Fondation Francqui-Stichting
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Ceremony of the Francqui Prize by Her Majesty the Queen at the "Palais des Académies" on June 9, 2015

Career - Research - Report of the Jury

Stefaan Vaes

Career

Stefaan Vaes was born on February 29, 1976 in Herentals. He is married to Annelies Maes and the proud father of two daughters, Eline and Margot. He studied Latin-Mathematics at the Sint-Jozef high school in Herentals. Already at school, he was fascinated by mathematical problems. Laureate of the Flemish Mathematical Olympiad, he was one of the six Belgian team members at the 1994 International Mathematical Olympiad in Hong Kong. Motivated by inspiring high school teachers, he started his mathematics studies at KU Leuven, where he obtained his degree in 1998. The same year, he started a PhD in mathematics with a PhD fellowship of the Fund for Scientific Research (FWO) and with Alfons Van Daele as his advisor.

During his PhD research, he collaborated intensively with Johan Kustermans and they developed the theory of locally compact quantum groups. That was also the title of the PhD thesis that Stefaan Vaes defended in 2001 at KU Leuven and that was rewarded with the Robert Stock Prize of the Academische Stichting Leuven. The FWO offered him the opportunity to spend the final year

of his PhD fellowship in Paris, in one of the world's main research centers in functional analysis.

Stefaan Vaes started to work in the operator algebra research group lead by Georges Skandalis. The vast dynamism of this group and the enormous offer of seminars and courses by mathematicians from all over the world marked a turning point in his career. In 2002, he was appointed as a permanent researcher of the Centre National de la Recherche Scientifique (CNRS), affiliated with the Institut de Mathématiques de Jussieu in Paris. This allowed him to pursue his research in complete freedom.

In 2004, he obtained his Habilitation at the Université Paris VII – Denis Diderot and in 2006, he was appointed as a Cours Peccot lecturer at the Collège de France. In 2005, his research changed course after contacts with Sorin Popa of the University of California at Los Angeles (UCLA). They started an intensive collaboration on the structure and classification of von Neumann algebras.

Stefaan Vaes returned to KU Leuven in 2006 as an associate professor. He obtained a Starting Grant of the European Research Council (ERC) that allowed him to build up his own research group in Leuven. In 2010, he was an invited speaker at the prestigious four-yearly International Congress of Mathematicians. Since 2012, he is a full professor and his research group is currently funded by an ERC Consolidator Grant. He also is an editor of several scientific journals, including the Journal of Functional Analysis, the Transactions of the American Mathematical Society and the generalist science journal Karakter. He received the Alumni Award of the Belgian American Educational Foundation and the prize of the Vlaamse Wetenschappelijke Stichting. Since 2012, he is a fellow of the American Mathematical Society.

Stefaan Vaes finds it important to increase the visibility and appreciation of mathematics among young people and the broad public. He is the coordinator of the Junior College STEM of KU Leuven, targeting pupils in the final years of secondary school. He also is one of the co-organizers of the mathematics exhibition IMAGINARY that will travel through Belgium from the fall of 2015 onwards.

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Research

Research in the classical fields of mathematics – algebra, analysis, geometry – is driven by the curiosity to discover and understand mathematical structures. This fascination is as old as the most ancient civilizations. Already in 300 BC, Euclid proved that there are infinitely many prime numbers. These are numbers as 2, 3, 5, 7 or 2017 that are only divisible by 1 and by themselves. Often such prime numbers appear in pairs, like 3 and 5, or 11 and 13, or 2027 and 2029. To this day, nobody knows if there exist infinitely many such twin primes.

If you kick a soccer ball, you can use classical mechanics to perfectly predict where the ball will land, in terms of the kick, the pressure in the ball, etc. This description of physical reality in terms of position and velocity of objects, is no longer applicable at the atomic scale. In quantum mechanics, the position and velocity of a particle are no longer uniquely defined quantities, but rather behave as matrices that, so the speak, can take multiple values at once.

In the 1920s, John von Neumann developed the mathematical formalism to correctly handle these matrices, that are moreover of infinite size and are then

called operators. This lead John von Neumann and Francis Murray in a series of groundbreaking articles, published between 1930 and 1943, to the development of von Neumann algebras, a mathematical structure in which several operators and their interactions can be described and studied. They also discovered that there exist several types of von Neumann algebras and that they appear in many different areas of mathematical analysis.

Von Neumann algebras often have a very symmetric structure, as if they can be rotated, reflected and translated. However they do not only have such classical symmetries, but also quantum symmetries. In his PhD research and during the subsequent years, Stefaan Vaes developed in collaboration with Johan Kustermans the theory of locally compact quantum groups, which is still used by many mathematicians. These quantum symmetry groups are strongly related to the work of Vaughan Jones on knot theory, in which von Neumann algebras are used to show that it is impossible to unravel certain knots.

Ever since the work of Murray and von Neumann, mathematicians try to understand how many different kinds of von Neumann algebras exist. Such a classification effort actually is a recurring theme in mathematics and the complete classification of all finite simple symmetry groups is one of the biggest successes of twentieth century mathematics; an impressive work published in more than 100 articles.

Although it is intrinsically impossible to obtain an equally complete classification of all von Neumann algebras, this is possible for certain families. In 1976, Alain Connes classified all small – in technical terms, amenable – von Neumann algebras. In a sustained collaboration with Sorin Popa, Stefaan Vaes managed to prove far reaching classification results for large families of non-amenable von Neumann algebras. They also discovered very exotic examples, including von Neumann algebras that have a fractal symmetry group.

This research is not directed towards immediate applications, but it is used. Von Neumann algebras are of crucial importance in quantum information theory, the informatics of quantum computers. If one day it would become possible to build real quantum computers, this would provide a gigantic increase in computational power. It would also mean that all modern cryptography can be broken. But in the meanwhile, passionate mathematicians as Stefaan Vaes remain fascinated by von Neumann algebras as such, and by many other centuries old problems in algebra, analysis or geometry.

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Report of the Jury (April 20 & 21, 2015)

Stefan Vaes has discovered ingenious solutions of long-standing problems in operator algebras, an important area of functional analysis that is noted for its difficulty and potential applicability to a broad range of scientific questions. He is a rare mathematician who has obtained remarkably deep results on the structure of operator algebras, and raised them to the level where they impact other fundamental fields of mathematics.

Following the emphasis in quantum mechanics on non-commutative operator algebras, Murray and von Neumann in the late 1930s and early 1940s formulated a comprehensive framework for systems with an infinite number of degrees of freedom. This framework opened up a broad range of difficult problems, which have been tackled by several generations of the world's leading mathematicians.

Vaes's work focusses on the structure and classification of non-commutative operator algebras. He has used novel methods to derive remarkably powerful solutions to several long standing problems in von-Neumann algebras. These have developed and vastly improved all existing techniques in this area, and inspired a generation of young mathematicians in Belgium and the rest of the world.

Jury members :

Professor David Gross
Is Chancellor's Chair Professor of Theoretical Physics and former Director of the Kavli Institute for Theoretical Physics at UCSB and was previously Thomas Jones Professor of Mathematical Physics at Princeton University. His discovery, with his student Frank Wilczek, of asymptotic freedom led to the formulation of Quantum Chromodynamics, the theory of the strong nuclear force. This completed the Standard Model, which details the three basic forces of particle physics--the electromagnetic force, the weak force, and the strong force. Gross was awarded the 2004 Nobel Prize in Physics for this discovery. He has also made seminal contributions to the theory of Superstrings. His awards include the Sakurai Prize, MacArthur Prize, Dirac and Oscar Klein Medals, Harvey Prize, the EPS Particle Physics Prize, the Grande Medaille d'Or. He holds honorary degrees from the US, Britain, France, Israel, Brazil, Belgium and China. His membership includes the National Academy of Science, the American Academy of Arts and Sciences, the American Philosophical Society, the Indian Academies of Science and the Chinese Academy of Science.

Chairman

and

Professor Roger Brockett
Is a Research Professor at Harvard University. He spent more than forty years on the faculty at Harvard University after spending a period teaching at MIT. His research spans a broad range of topics in engineering and applied mathematics. He is a member of the US National Academy of Engineering and is the recipient of major prizes from IEEE (Institution of Electrical and Electronic Engineers), ASME (American Society of Mechanical Engineers) and SIAM (Society of Industrial and Applied Mathematics), for his work on the theory of automatic control. He is a fellow of the American Mathematical Society, SIAM, and the IEEE.

Professor Nello Cristianini
Is a Professor of Artificial Intelligence at the University of Bristol, a former recipient of the Royal Society Wolfson Research Merit Award and a current holder of a European Research Council Advanced Grant. His current research spans the fields of Machine Learning, Data Science and Computational Social Sciences, focussing on the large scale automated analysis of news and social media content. Another key concern of Cristianini are the social and ethical implications of the Big Data revolution, and the urgent need to understand its risks in order to inform new legislation. Before working at Bristol, Cristianini was a Professor of Statistics at the University of California, Davis.

Professor James L. Crowley
Is Professor of Informatics and Applied Mathematics at Grenoble Institut Polytechnique in Grenoble, France. He performs research on computer vision, robotics, and intelligent systems at the INRIA Grenoble Rhône-Alpes Research Center. Over the last 30 years, professor Crowley has made fundamental contributions to computer vision and mobile robotics, including early innovations in scale invariant computer vision, perception for mobile robots, architectures for autonomous systems, machine perception for human computer interaction, and appearance-

based techniques for object recognition. Professor Crowley has been named Chevalier de l'Ordre Nationale de Mérite and is a Senior Member of the l'Institut Universitaire de France (IUF).

Professor Simon Deleonibus

Chief Scientist at CEA-LETI; PhD 1982; IEEE Fellow; IEEE Distinguished Lecturer; CEA Research Director; Visiting Professor Tokyo Institute of Technology; “Chevalier de l’Ordre National du Mérite”; “Chevalier de l’Ordre des Palmes Académiques”; “2005 Grand Prix de l’Académie des Technologies”; Chair IEEE Electron Dev. Soc. Region 8; Member of ITRS, ERC Panel, Nanosciences Foundation and IEEE Electron Dev. Soc. Board of Governors;

Professor Faddeev Ludwig Dmitrievich

Studied at Physics Dept. of Leningrad University and from 1961 works at Steklov Mathematical Institute of Russia Academy of Sciences as junior, senior and leading scientist. Main direction of work is Mathematical Physics.
President of International mathematical Union 1986-1990. Organizer of Euler International Mathematical Institute in St.Petersburg.Member of Russian Academy of Sciences from 1976, foreign member of several National Academies , those of France, USA, China among others and London Royal Society.

Professor Dr. Claudia Felser

Studied chemistry and physics at the University of Cologne (Germany) and completed her doctorate in physical chemistry there in 1994. After postdoctoral fellowships at the MPI in Stuttgart and the CNRS in Nantes (France), she joined the University of Mainz and became a full professor at the University of Mainz (Germany) in 2003. She was a visiting scientist at Princeton University (USA) in 1999 and at Stanford University in 2009/2010 and a visiting professor at the University of Caen (France). In Dec. 2011, she became director at the Max Planck Institute for Chemical Physics of Solids in Dresden (Germany). She is the chair of the DFG research group “New Materials with High Spin Polarization” and was the director of the Graduate School of Excellence “Materials Science in Mainz” of the German Science Foundation (DFG) from 2007-2012.

Professor Roderick J. Little is Richard D. Remington Distinguished University Professor of Biostatistics at the University of Michigan. He is a statistician who develops methods for the analysis of data with missing values and model-based survey inference, and applies statistics to diverse scientific areas, including medicine, demography, economics, psychiatry, aging and the environment. Little is an elected member of the International Statistical Institute, a Fellow of the American Statistical Association and the American Academy of Arts and Sciences, and a member of the Institute of Medicine of the U.S. National Academies.

Professor David Marshall

Is Professor of Physical Oceanography and Head of Atmospheric, Oceanic and Planetary Physics at the University of Oxford. He is recipient of the 2014 Appleton Medal and Prize of the Institute of Physics “for his fundamental contributions to understanding the fluid dynamics of the global ocean circulation through the development of penetrating conceptual models”. He studied at Imperial College, London, where he obtained a first degree in Physics and a Doctorate in Physical Oceanography. He spent three years as a post-doctoral researcher at MIT, before returning the UK to establish the Physical Oceanography Group at the University of Reading; his research group relocated to Oxford in 2007.

Professor Sir John Meurig Thomas

Is an Honorary Professor at the Dept of Materials Science, University of Cambridge. Formerly he was Head of the Department of Physical Chemistry at Cambridge, Master [Head] of the oldest college in Cambridge[Peterhouse] and Director of the Royal Institution of Great Britain and of the Davy-Faraday Laboratory, London.He is renowned for his work in heterogeneous catalysis and in chemical electron microscopy.He has received several national and international prizes and is the holder of the Willard-Gibbs, Pauling, Stokes, Kapitza, and Zewail gold medals and also the Davy medal of the Royal Society, the Faraday medal of the Royal Chemical Soc of the UK and the Blaise Pascal medal of the European Academy of Sciences.

Professor Dr. h.c. Hartmut Michel

Is director at the Max Planck Institute of Biophysics in Frankfurt am Main, Germany. He is a

biochemist by education and tries to work out how membrane proteins work. These proteins are responsible for signal reception, for specific transport across membranes and for biological energy conversion. Michel received the Nobel Prize of Chemistry in 1988 for the first determination of the atomic structure of a membrane protein.

Professor Dr. Angel Rubio

s Director and Scientific Member at the Max Planck Institute for the Structure and Dynamics of Matter as of August 2014. He is also Professor for condensed matter physics at the University of the Basque Country in Donostia-San Sebastián, Spain, Vice-president for Scientific Development of the European Theoretical Spectroscopy Facility (ETSF) and Foreign Scientific Member of the Fritz Haber Institute of the Max Planck Society in Berlin. His research interests include the theory and the modeling of electronic and structural properties of condensed matter, and the development of new theoretical tools to investigate the electronic response of nanostructures, biomolecules and hybrid materials to external electromagnetic fields. His group is one of the worldwide references in the field of simulation and modeling of materials, nanostructures, and biomolecules.

Professor Rubio is author and coauthor of more than 300 scientific publications with more than 21,500 citations (Hirsch index 74). Since 2004 he is Fellow of the American Physical Society (APS) and since 2010 Fellow of the American Association for the Advancement of Science (AAAS). In 2014 he was elected Foreign Associate Member of the U.S. National Academy of Sciences (NAS). He received numerous scientific awards, among them in 2005 a Friedrich Wilhelm Bessel Research Award of the Alexander von Humboldt Foundation, in 2011 an Advanced Grant of the European Research Council (ERC), and in 2014 the renowned Spanish Premio Rey Jaime I in the area of Basic Science.

Professor Joachim Saur

Is a professor for geophysics at the University of Cologne, Germany. He studies moons, planets, exoplanets and their plasma environments with telescopes, numerical simulations, and theory. He is also interested in turbulence in space plasmas. Joachim Saur previously worked at the Observatory in Nice, France, and the Johns Hopkins University in Baltimore, USA. He studied Physics at the Universities of Stuttgart and Cologne, and earned his doctorate in Geophysics from the University of Cologne in 2000.

Professor Peter Zoller

Is Professor of Physics at the University of Innsbruck, Austria, and Scientific Director at the Institute for Quantum Optics and Quantum Information (IQOQI) of the Austrian Academy of Sciences. He is best known for his pioneering research on quantum computing and quantum communication and for bridging quantum optics and solid-state physics. As a theoretician, Peter Zoller has written major works on the interaction of laser light and atoms.

Members

Professor Matthias Scheffler

Matthias Scheffler is director of the Theory Department at the Fritz Haber Institute of the Max Planck Society in Berlin, Germany.

His research activities are focused on fundamental aspects of the chemical and physical properties of surfaces, interfaces, clusters, nano-structures, and solids. Studied processes are relevant for energy and environment science, specifically optoelectronics, photovoltaics, heterogeneous catalysis, and thermoelectrics.

Associate Member

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