Fondation Francqui-Stichting
Fondation d'Utilité Publique - Stichting van Openbaar Nut

Ceremony of the Francqui Prize by His Majesty The King at the Fondation Universitaire on June 13, 2012

Biography - Research - Report of the Jury

(photos of the Ceremony)

Conny Aerts

Biography of Conny Aerts

Conny Aerts was born on 26 January 1966 in Brasschaat, Belgium. Already in primary school, she got interested in the Universe. After her secondary school education at the Instituut Onze-Lieve-Vrouw of Antwerp, she studied mathematics at Antwerp University (1984 - 1988), specialising in mathematical physics. She continued her education with PhD studies in astrophysics at Leuven University under the supervision of Christoffel Waelkens (1988-1993). She developed rigorous mathematical methodology to identify stellar oscillation modes from

time series of high-resolution spectroscopy and made the first applications in this research domain within stellar astronomy. In order to achieve this, she performed numerous observing runs of several consecutive weeks at the international observatories situated in the Chilean Atacama dessert and in the French Alpes des Haute Provence. Her method saw widespread application until the present day. She defended her PhD thesis in 1993, one year prior to the end of her university assistantship, which included a teaching task of six hours per week. She profited of the last year of her assistantship to perform a research stay of several months at the University of Delaware in the USA to broaden her scope towards radiation-driven wind theory applicable to the most massive stars in the Universe.

After her PhD studies, Conny Aerts obtained a postdoctoral fellowship of the Fund for Scientific Research of Flanders (FWO, 1994 -- 2001) to develop her own independent research career, which

she started with a pregnancy and parental leave of five months. She profited of this time off to work her way into the topic of variable stars, preparing herself to exploit the new data obtained by the satellite Hipparcos of the European Space Agency. As soon as the data became public, she applied her statistical classification methods based on multivariate Gaussian mixtures to discover more than one hundred previously unknown variable stars with periodicities of the order of days. After a second pregnancy and parental leave, she started preparing her team to take part in the French-led European space mission CoRoT, which combined her two main research areas. Still within her postdoc position, she got elected as vice-president (2000 – 2003) and president (2003 - 2006) of Commission 27: “Variable Stars'”, of the International Astronomical Union, where she guided many hundreds of scientists in that field worldwide.

Conny Aerts was appointed as Lecturer at Leuven University in 2001. In that same year, stochastic oscillations comparable to those of the Sun were firmly established in distant stars. This led to the whole new branch of asteroseismology within stellar physics, in which oscillations of stars are used to probe their internal physics which is otherwise unreachable for experiment. Conny Aerts became one of the pioniers of this research field.

With her special appointment as Part-time Professor occupying the Chair in Asteroseismology at the University of Nijmegen in the Netherlands, she also got promoted to Associate Professor at Leuven University. Her part-time Dutch appointment allowed her to develop a meanwhile internationally recognised expertise pole in asteroseismology of compact stars, bridging the expertise of the Leuven and Nijmegen astrophysics teams.

As of 2007, Conny Aerts is Full Professor at Leuven University. She is member of various national and international research committees worldwide, both in fundamental science and in space science. In 2009, the European Reseach Council awarded her an Advanced Grant in asteroseismology to fund her research project based on data of the NASA space mission Kepler launched in 2009. Meanwhile, her ERC team led several publications in the prestigious journals Nature and Science, reporting on, among other things, the seismic derivation of the internal rotation rate inside stars.

In 2010, the Royal Astronomical Society of the United Kingdom awarded Conny Aerts with an “Honorary Fellowship'” and, one year later in 2011, she became member of Royal Flemish Academy of Belgium for Sciences and the Arts. Until the present day, Conny Aerts supervised 52 PhD and master thesis students in astrophysics.

Conny Aerts is married and proud mother of a daughter An (born 1994) and a son Jasper (born 1998). When not working, you can find her jogging in the forrest close to her house, at the soccer games of her son, at the sauna, or sipping champagne while chatting with frieds.

* * *

Research of Conny Aerts

Stars are the building blocks of galaxies and, by implication, also of the Universe. Understanding the evolution of the Universe thus requires understanding stellar evolution. The life of stars is determined by the physical processes which occur in their interior, which are unfortunately not within reach for direct experiments. Asteroseismology is a recent method to probe internal stellar physics, based on the detection and interpretation of the oscillations of stars. By comparing the observational properties of stellar oscillations with those predicted by theoretical models, one has a powerful tool to improve stellar models and develop a better stellar evolution theory.

The research of the team led by Conny Aerts covers the broad field of the structure and evolution of

stars of various masses, chemical composition and age, with specific attention to their oscillations. The Leuven asteroseismology team developed into a recognised expertise centre in oscillation mode identification, which is a necessary step for any successful seismic modelling. It requires a careful and mathematically solid interpretation of time series of high-precision spectroscopic of multicolour photometric data. A revolution in observational asteroseismology is presently ongoing, thanks to the operational space missions CoRoT (French-led European, launched 2006) and Kepler (American, launced 2009), providing uninterrupted data with a factor 100 better precision than what can be reached from ground-based observatories.

Asteroseismology requires first of all to find the stars with the most interesting oscillations. With the advent of technology and the organisation of large stellar surveys from the ground and from space, the search for stellar oscillations moved from visual eye-based methods to machine-learning methodology which can be applied to peta-byte sized databases. The Leuven team developed supervised Gaussian mixture classification methodology and applied it to various databases. This resulted in the discovery of numerous new variable stars, among which hundreds of stars with slow oscillations having periodicities of the order of days. Along with ground-based spectroscopy, this classification served as basis for presently ongoing extensive follow-up studies.

The team of Conny Aerts published ground-braking results on the internal rotation of stars. Just as the audience hears the musical tones played by an orchestra change if the podium starts rotating compared to when it stood still, the frequenties of stellar oscillations are shifted compared to the case where the star does not rotate. Moreover, if the internal stellar layers rotate differently than the surface layers, then the small oscillation frequency shifts reveal this differential rotation. Unravelling such frequency shifts typically requires months to years of uninterrupted data. The Leuven team thus found the cores of various types of stars to rotate faster than their surface, implying rotational mixing to be included in a new generation of stellar evolution models.

* * *

Report of the Jury (April 1-2, 2012)

Conny Aerts has made seminal contributions to the study of stellar physics, mainly through her work in *asteroseismology*, the investigation of properties of stars based on observations of the oscillations of their surfaces.

This field is similar to seismology of the Earth. The oscillations of a star depend on its mass, radius, and on the physical conditions in the stellar interior. Despite the enormous distances over which observations are made, minute surface oscillations can tell us about the physical processes that control the structure and evolution of the stars. The resulting understanding of stellar evolution is crucial in broad areas of astrophysics. In the case of our Sun, the study of solar oscillations has provided detailed insights into the solar interior. The application of similar methods to distant stars has developed rapidly in recent years, in large measure thanks to the efforts of Conny Aerts. The field of stellar oscillations has a strong Belgian heritage, the theoretical foundations having been established by Paul Ledoux, Université de Liège (who won the Francqui Prize in 1964).

The early work of Aerts, developed as part of her PhD studies, concerned the identification of oscillation modes from their effect on the shape of spectral lines. Such mode identification is crucial for the comparison between observations and theoretical stellar models, and hence for the use of the observed oscillation frequencies to investigate the properties of the stellar

interiors. Her work involved a sophisticated analysis of the interplay between the geometry of the modes and the observational techniques. Her methods have seen widespread use in increasingly ambitious observations of stellar oscillations.

Her subsequent work has turned in a more observational direction, while always maintaining contact with the more theoretical aspects, and with an impressive breadth. She successfully used data from the European Space Agency's Hipparcos mission to identify a large number of slowly pulsating stars and carried out extensive ground-based follow-up observations of these stars. To obtain data of sufficient duration and quality she organized major internationally coordinated observing campaigns involving telescopes around the world, and on that basis for the first time obtained information about the core structure and internal rotation of massive stars that may later evolve into supernovae.

In the last few years asteroseismology has been dominated by a huge increase in the amount and quality of data from space-based observations. Aerts played an important role involving Belgium in the CoRoT mission launched by the "Centre Nationale d'Etudes Spatiales". Together with a group of brilliant PhD students she has obtained very important results from the data obtained from the CoRoT and the NASA *Kepler* missions. The most significant results have been in the study of red-giant stars, where her group was the first to identify the presence of non-radial oscillations and subsequently obtain detailed information about the structure and rotation of the compact helium cores of these stars.

Jury members :

Professor Dr. Jørgen Christensen-Dalsgaard
Department of Physics and Astronomy - Professor of helio- and asteroseismology and head, Stellar Astrophysics Centre, **Aarhus University, Denmark**. Education: MSc 1975, Aarhus University; PhD 1978, Cambridge University (UK). Postdoc positions in Liege, Belgium, Boulder, Colorado, and Copenhagen, Denmark. Research in solar and stellar structure and oscillations and seismic investigations of stars. Head of the Kepler Asteroseismic Science Consortium and the Stellar Observations Network Group (SONG) project.

Professor dr. ir. R.A.J. René Janssen
Departments of Applied Physics and Chemical Engineering and Chemistry - **Eindhoven University of Technology** - René Janssen is full professor in applied physics and chemical engineering and chemistry at the Eindhoven University of Technology in **The Netherlands**. His research activities focus investigating electronic and optical properties of novel semiconducting molecules, macromolecules, nanostructures, and materials that may find application in advanced technological optoelectronic applications such as solar cells

Professor Dr. Dr. h.c. Hartmut Michel
1988 Nobel Laureate in Chemistry
Hartmut Michel is director at the **Max Planck Institute of Biophysics** in **Frankfurt am Main**. He is a biochemist by education and tries to work out how membrane proteins function. These proteins are responsible for signal reception, specific transport across membranes and biological energy conversion. Michel received the Nobel Prize of Chemistry for the first determination of the atomic structure of a membrane protein in 1988

Professor Dr Dusa McDuff, FRS

Helen Lyttle Kimmel '42 Professor of Mathematics - Department of Mathematics- **Barnard College/ Columbia University - USA** - Born in London in 1945, Dusa McDuff was educated at the Universities of Edinburgh and Cambridge, where she received a Ph. D. in Mathematics in 1970. She currently is Kimmel Professor of Mathematics at Barnard College, and specializes in symplectic topology. She is a Fellow of the Royal Society and a member of the National Academy of Science

Professor Dr. David J. Norris
Professor David J. Norris is currently the Director of the Optical Materials Engineering Laboratory at **ETH Zürich**. Prof. Norris received his B.S. and Ph.D. degrees in Chemistry from the University of Chicago (1990) and MIT (1995), respectively. After a NSF postdoctoral fellowship at the University of California, San Diego, he joined the NEC Research Institute in Princeton in 1997. He was then an Associate Professor (2001-2006) and Professor (2006-2010) of Chemical Engineering and Materials Science at the University of Minnesota.

Professor Michael L. Overton
Professor of Computer Science and Mathematics- Chairman op the Computer Science Department - Courant Institute of Mathematical Sciences - **New York University - USA**

Professor Michele Parrinello
ETH Zurich and **Università della Svizzera Italiana**, Lugano, Switzerland
Professor Parrinello is known for his many technical innovations in the field of atomistic simulations and for a wealth of interdisciplinary applications ranging from materials science to chemistry and biology. For his work he has been awarded the 2011 Prix Benoist and many others prizes and honorary degrees. He is a member of numerous academies and learned societies, including the National Academy of Science, the British Royal Society and the Italian Accademia Nazionale dei Lincei. He is the author of 550 papers, which have received 34'000 citations with an h-index of 94.

Professor John Preskill
The Richard P. Feynman Professor of Theoretical Physics - California Institute of Technology - John Preskill is the Richard P. Feynman Professor of Theoretical Physics at the California Institute of Technology, and Director of the Institute for Quantyn Information at Caltech. Preskill received his A.B. in physics in 1975 from Princeton, and his Ph.D. in physics in 1980 from Harvard. He was a Junior Fellow in the Harvard Society of Fellows and Associate Professor of Physics at Harvard before joining the Caltech faculty in 1983; he became the John D. MacArthur Professor in 2002, and the Richard R. Feynman Professor in 2010. Until the mid-1990s, Preskill's research focused on elementary particles, cosmology, and gravitation. Since then his research has focused primarily on quantum computation and quantum information theory.

Professor Dr 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

Professor Dr. Herbert Spohn
Zentrum Mathematik, M5 - Technische Universität München
Herbert Spohn received his Ph.D. in physics at the L**udwig-Maximilians-Universit -Munchen**. He is now professor for Mathematical Physics at the Zentrum Mathematik, Technical University Munich, with joint appointment by the Physics Department. His main research focus is non-equilibrium statistical mechanics.He has published ``Large Scale Dynamics of Interacting Particles" at Springer-Verlag and ``Dynamics of Charged Particlesand Their Radiation Field" at Cambridge University Press. Spohn was awarded the 2011 Dannie Heineman Prize for Mathematical Physics, the 2011 Leonard Eisenbud Prize for Mathematics and Physics and the 2011 Caterina Tomassoni Prize.

o.Univ. Professor Dr. Anton Zeilinger

Quantum Optics, Quantum Nanophysics, Quantum Information - **University of Vienna** - Anton Zeilinger is Director of the Institute for Quantum Optics and Quantum Information Vienna, Austrian Academy of Sciences, and Professor of Physics, University of Vienna. He carries the Inaugural Isaac Newton Medal (Institute of Physics, 2007), and the Wolf Prize in Physics (2010). His career includes the Massachusetts Institute of Technology (M.I.T.), and the Collège de France.