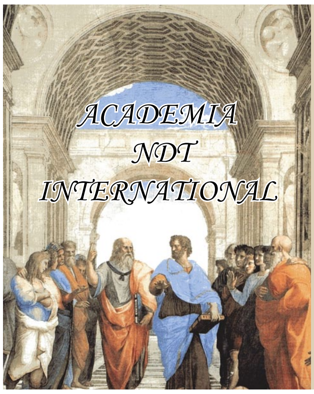


Lectio Materia

Newsletter of the

ACADEMIA NDT INTERNATIONAL

Science, Technology and Diagnostics in Non-Destructive Testing

Academia NDT International scientific meetings at WCNDT

ACADEMIA NDT International, the organisation for science, technology and diagnostics in non-destructive testing with the aim of advancing the science of NDT, is proud to host a series of two scientific meetings to take place within the programme of the 18th World Conference on NDT being held in Durban, South Africa, from 16-20 April 2012. Both meetings are to feature keynote lectures by Nobel Laureate Sir Harold Kroto.

The programmes for the meetings, which are both open to all, are shown below.

Sir Harold (Harry) Walter Kroto, FRS, is a British chemist and one of the three recipients to share the 1996 Nobel Prize in Chemistry along with Robert Curl and Richard Smalley.

In the 1970s, he launched a research programme at the University of Sussex to look for carbon chains in the interstellar medium. The work led to the discovery of the C60 molecule – the spherical fullerene molecule known as the Buckminsterfullerene (or Buckyball). Buckminsterfullerene is the largest matter to have been shown to exhibit wave–particle duality. Its discovery led to the exploration of a new field of chemistry, involving the study of fullerenes.

Because the ACADEMIA NDT scientific meetings are integrated into the programme of the World Conference and are free for participants, persons planning to attend the scientific meetings arranged by the ACADEMIA should communicate their intention to the Executive Secretary of the ACADEMIA, Dr Irena Pushkina, by email: pushkina@spektr-group.ru

In the time since its birth, the ACADEMIA NDT has achieved a great deal – most notably its membership has grown considerably and four memorable special lecture meetings have been held: the first in Shanghai, coinciding with the 17th World Conference on NDT; the second and fourth in Brescia, Italy, the official seat of the organisation; and the third alongside the 10th European Conference on NDT, held in Moscow in 2010.

Giuseppe Nardoni President, ACADEMIA NDT International

The idea of the ACADEMIA NDT International emerged a few years ago, reflecting a need within the NDT community to have a body that is evidence of the science in the NDT field at the highest level. A Steering Committee was formed and met for the first time on 25 May 2007 in Opatija, Croatia. An official decision to establish the ACADEMIA was taken on 10 March 2008, in Moscow. The overall objective of the ACADEMIA is to foster research, development and education in the NDT field by engaging NDT professionals in a combined effort, thus attaining the goal of always seeking progress.

Giuseppe Nardoni, President of the ACADEMIA NDT International, has referred to the organisation as "the greatest gift we can make to the new generation of NDT."

ACADEMIA NDT International Scientific Meetings

International Convention Centre, Durban

ALL WELCOME

Session 1: Tuesday 17 April 2012, 14:00-17:00, Room MR22

Session 2: Wednesday 18 April 2012, 18:00-19:00, Room 1A/B

Session 1: Tuesday 17 April 2012

Chairmen: Giuseppe Nardoni (President, ACADEMIA NDT) and Dr Baldev Raj (Vice President, ACADEMIA NDT)

14:00 – 14:30 **Welcome and Introduction**

14:30 – 15:00 **1. Lecture: 'Non-linear ultrasonic time-reversal mirrors in NDT'**
Dr Zdenek Prevorovsky, Czech Academy of Science

15:15 – 16:00 **2. Lecture: 'Carbon in nano and outer space'**
Sir Harold Kroto, Florida State University, USA

16:00 – 16:30 **3. Lecture: 'Nanosensors'**
Dr Marc Kreutzbruck, BAM, Germany

16:30 – 17:00 **4. Lecture: 'Potential of terahertz radiation in NDT'**
Professor Uwe Ewert, BAM, Germany

Session 2: Wednesday 18 April 2012

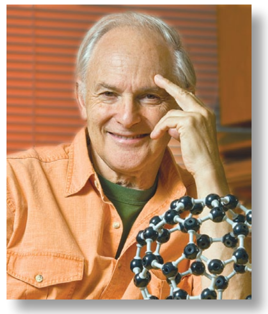
Chair: Giuseppe Nardoni (President, ACADEMIA NDT)

18:00 – 19:00 **1. Lecture: 'Scientific research as a key stimulus of socio-economic development'**
Sir Harold Kroto, Florida State University, USA

Programme at time of going to press. Please note there may be last-minute unavoidable alterations.

Sir Harold Kroto

Biography & Abstracts



Sir Harold (Harry) Kroto is currently a Francis Eppes Professor of Chemistry at Florida State University, where he is carrying out research in nanoscience and cluster chemistry as well as developing exciting new internet approaches to STEM educational outreach. In 1996, he was knighted for his contributions to chemistry and later that year was one of three recipients of the Nobel Prize for Chemistry. He is a Fellow of the Royal Society of London and holds an emeritus professorship at the University of Sussex, Brighton, UK. The research programme focuses on the complex range of molecular constituents in carbon vapour; the development of novel 2 and 3D metal-cluster/organic frameworks as well as peptides; the stabilisation of small fullerenes; and the behaviour of carbon nanotube-based devices.

Harry obtained a first class BSc honours degree in Chemistry (1961) and a PhD in molecular spectroscopy (1964) at the University of Sheffield, UK. After post-doctoral positions at the National Research Council in Ottawa, Canada (1964-66), and at the Murray Hill Bell Laboratories, New Jersey, USA (1966-67), he started his independent academic career at the University of Sussex. In 1970, his research group conducted laboratory began spectroscopic studies on long linear carbon chain molecules with colleague David Walton. This research led to radio astronomy searches with Takeshi Oka and Canadian astronomers (Lorne Avery, Norman Broten and John McLeod) at the National Research Council in Canada, which made the surprising discovery that they existed in unusually copious amounts in certain regions of interstellar space. At the same time, he developed flash thermolytic synthetic methods to create new metastable species and intermediates with multiple bonds between carbon and second and third row atoms (S, Se and P), and applied microwave spectroscopic techniques to detect and characterise them. The work on multiple bond carbon-phosphorus species (with Sussex colleague John Nixon) created the first molecule with a C=P double bond and the second with a C≡P triple bonded species. The general synthetic techniques developed opened up the exciting new fields of Phosphaalkene and Phosphaalkyne Chemistry. Conclusions derived from the earlier radioastronomy breakthrough on carbon species in space led to experiments in 1985, together with Robert Curl, Richard Smalley and research students Jim Heath, Sean O'Brien and Yuan Liu, at Rice University, Texas, USA. These laboratory experiments, which simulated the chemical reactions in the atmospheres of red giant stars, uncovered the existence of C60 Buckminsterfullerene, the third well-characterised form of carbon, for which he, together with Curl and Smalley, received the 1996 Nobel Prize in Chemistry.

In 1995, he launched the Vega Science Trust (www.vega.org.uk) to create science films of sufficiently high quality for broadcast on UK network television. He is now heavily involved with GEOSET, the Global Educational Outreach for Science, Engineering and Technology programme (www.geoset.info and www.geoset.fsu.edu), which he initiated after moving to Florida State University. GEOSET seeks to exploit the revolutionary creative dynamics the internet (which Harry calls the GooYouWiki-World) to improve the general level of science understanding and awareness worldwide. Numerous universities in the US, the UK, Japan, Croatia and Spain are now contributing to GEOSET's rapidly growing, globally accessible and freely available cache of science educational material in modular form designed to help teachers. An exciting aspect of this initiative has been the revelation that graduate and undergraduate students are often exceptionally good at creating educational modules.

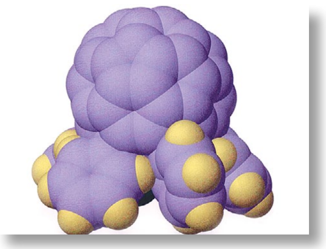
Harry has numerous awards, including the Copley Medal, the Faraday Lectureship of the Royal Society as well as the Tilden Lectureship and Longstaff Medal of the Royal Society of Chemistry. Other awards include the Louis Vuitton – Moet Hennessy Science pour l'Art Prize and the Italgas Prize for Innovation. He holds some 36 honorary degrees from universities all over the world and is a Freeman of the City of Torino. From 2004, he has been on the Board of Scientific Governors at Scripps Institute. He was elected a Foreign Associate of the National Academy of Sciences in 2007.

Carbon in nano and outer space

Sir Harold Kroto, Florida State University, USA

The age-old awe that man has had for the heavens has driven almost all aspects of human culture and knowledge and resulted in technologies with a generally positive, though occasionally negative, effect. In fact, it was only in the 16th Century when mankind finally applied the new doubt-based, evidence-dependent analytical method, the metric then known as natural philosophy, to the motions of the planets that science was born. From that moment we started to rely more on science and an understanding of why things work the way they do than on the 'common sense' which is generally all that is needed to survive. This change occurred when Galileo used his telescope and realised that the phases of Venus provided the incontrovertible evidence that confirmed the Copernican heliocentric system, which cemented his position as one of, if not the, 'Father of Science'. Thus science itself was born out of curiosity, not expedience, and it is still true today that almost all major breakthroughs are made by the openly curious who generally discover what those with more focused minds tend to overlook.

With the development of radiotelescopes during the last half of the 20th Century, the very cold interstellar medium was found to be a veritable Pandora's Box, full to the brim with fascinating and exotic molecules and dust particles, as well as some highly puzzling material responsible for some as yet unidentified optical features. Particularly fascinating, curious and crucial has been the role that the element carbon has played in almost every aspect of the development of our understanding of both the physical and natural sciences. The fact that the element is at all abundant is due to a curious set of coincidences involving its nucleosynthesis from helium in stars. If one furthermore adds into the overall carbon equation its uniquely profuse chemistry, *ie* organic chemistry, which is also the basis of biology, it is hard to conceive that life could be based on any other element. The most recent big surprise that the element had up its sleeve was the existence of C60, Buckminsterfullerene, the third well-defined form of carbon – the other two being graphite and diamond. The discovery of this molecule and its siblings (the whole family now known as the Fullerenes) was made serendipitously during laboratory experiments that attempted to explain the chemical synthesis of some unexpectedly long linear carbon chain molecules, which we detected in the interstellar medium. Follow up work from the C60 discovery also led to the re-discovery of carbon nanotubes, which promise paradigm shifting advances in materials engineering.



Structure of C60Ph5H

The fact that this third, well-defined, form of carbon had been hiding in the shadowy corners of the universe since time immemorial brings to mind the mysterious character lurking in the dark streets of Vienna, made famous by Orson Welles in the classic movie 'The Third Man'. Especially compelling support for the idea that C60 existed in space lay in the fact that the original discovery was made serendipitously during laboratory experiments designed to simulate the atmospheric conditions in cool red giant carbon stars. This conjecture was confirmed in 2010 by tell-tale signatures found in infrared spectra obtained by NASA's Spitzer satellite telescope.

This is yet another example of the remarkable way in which the fascination with space has catalysed fundamental breakthroughs in general science with major implications for innovative technological applications on Earth. In these difficult times, this account provides evidence which supports the vital role that fundamental cross-disciplinary research has played in the past, and will continue to play in the future, in providing totally unpredictable advances of major strategic importance. It is rather important to consider the fact that although there are scores of applied science laboratories around the world focused on combustion processes and many thousands of papers purporting to explain the process, this key species evaded them. There is food for thought in the fact that C60 is now being made commercially by a relatively simple combustion technique, yet when it was first proposed that it might play some role in combustion the most fierce antagonism to this proposal came from some members of the combustion research community. The history of scientific progress carries a serious health warning for those who think that fundamental science can be steered by bureaucratic decision-making, and the story of the discovery of the third form of carbon and its key role in the birth of nanoscience and nanotechnology is yet another example.

Scientific research as a key stimulus of socio-economic development

Sir Harold Kroto, Florida State University, USA

This lecture will deal with a wide range of scientific issues: a) how science has created the modern world, bringing widespread freedom from disease and releasing the human race from the slavery of working just to survive; b) some exciting recent breakthroughs which promise even more benefits as the 21st Century unfolds; c) what science actually is and who does it; and d) how new educational initiatives are developing the internet to improve science education in general and in the developing world in particular. The presentation will also deal with e) the responsibility to society that those who have acquired scientific understanding must shoulder.

Professor Uwe Ewert

Biography & Abstract

Born in the southwest of Berlin, Professor Ewert studied chemistry at the Humboldt-Universität Berlin with the final degree equivalent to a PhD in 1979. He spent his postdoctoral time in the Academy of Science of the German Democratic Republic (DDR), the same site as Dr Angela Merkel, currently the Chancellor of the Federal Republic of Germany. In 1989-90, he took the opportunity of accepting a fellowship at Cornell University in Ithaka, New York, USA. This was made possible within DDR's ambition to advance the international acceptance of scientific achievements.

Professor Ewert was overcome by the German reunification while being far away from home. Returning to Germany, he firstly became self-employed before joining the laboratory of radiation methods of BAM in 1992. Carrying computed tomography into the field was one of his primary commitments. In his approach, the X-ray tube and a digital matrix detector are guided mechanically around a tube inspecting seam welds and searching for flaws invisible from the outside. In 1998, a patent was granted for this kind of mechanical radiologic inspection method.

Another area he took a deep interest in was advancing computed radiography with phosphor imaging plates, originally introduced for medical applications in the early 1990s. His intention was to transfer this technology to technical applications, such as non-destructive testing, while being well aware that the requirements in these two areas are quite different. Later, the success of adapting this technology for NDT purposes, achieved in cooperation with film manufacturers, was documented in CEN and ASTM standards published in 2005.

During his career, Professor Ewert was appointed as Director and Professor at BAM, heading the Non-Destructive Testing and Characterisation: Radiological Methods division in 2001. Further recognitions followed, such as the DGZfP's Berthold Prize along with his colleague Bernhard Redmer, awarded for the portable device 'TomoCAR' for on-site tomographic inspections in 2005. Two years later, his co-workers Dr Uwe Zscherpel and Dr Klaus Bavendiek received the same prize for significant improvements of the contrast sensitivity of digital radiological technologies. Professor Ewert is also involved in the emerging mm-wave and terahertz technologies as well as in advanced security applications of radiological methods.

Potential of terahertz radiation in NDT

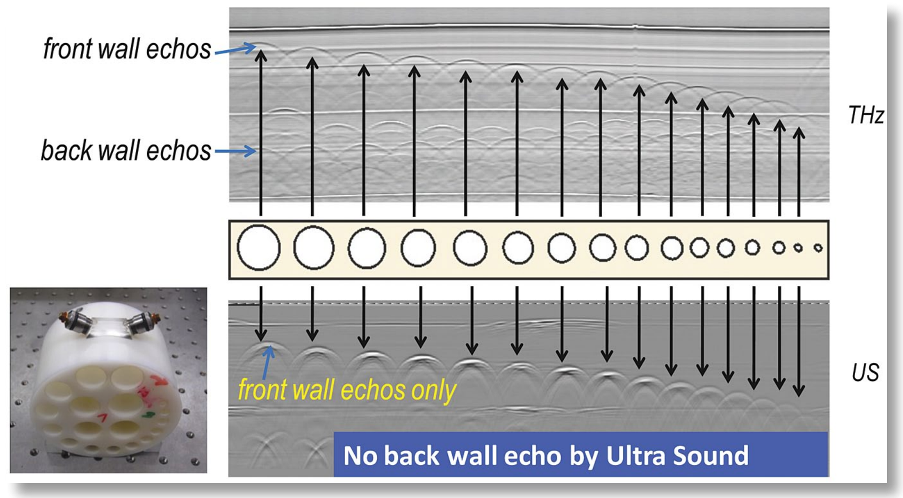
Professor Uwe Ewert, Radiological Methods, BAM Federal Institute for Materials Research and Testing, Berlin, Germany

Electromagnetic waves with frequencies between 0.3 and 6 terahertz (THz) are described as THz radiation (T-ray's). They are assigned in the electromagnetic spectrum between the microwave and the far-infrared regions. New technological developments enabled the construction of new THz generators and detectors.

During the last decade, mm-wave and THz technology became popular for security applications and NDT in aerospace. The technique can be applied for volumetric inspection as well as for visualisation of objects behind insulation materials such as paper, foam or clothes. For volumetric examination of materials' integrity, it is necessary to find planar material separations as well as volumetric voids within the object.

The classic testing methods are ultrasound testing (UT) and radiography, which are characterised by different probabilities of detection for planar material separations in dependence on the direction of the material separation. Radiography is able to detect planar defects, oriented in the direction of the X-ray beam. UT detects best planar defects perpendicularly oriented to the sound direction. UT detects efficiently defects oriented parallel to the surface, eg delaminations, but the first discontinuity on top hides all defects below. THz imaging technologies for non-metallic materials show some similarities to UT, because THz testing can be applied in a pulse echo (PE) technique.

Using the THz imaging technique is a way to overcome the limitations of UT. The THz PE technique does not require any coupling agent and also detects flaws behind a delamination. Furthermore, the reflected echos can be used for spatial reconstruction techniques in analogy to synthetic aperture radar. A modified synthetic aperture focusing technique (SAFT) known from UT is applied. This method also allows the inspection of large objects which are accessible on one side only.



Comparison of THz and ultrasound pulse echo technique of a polyethylene cylinder with side-drilled holes

ACADEMIA NDT INTERNATIONAL

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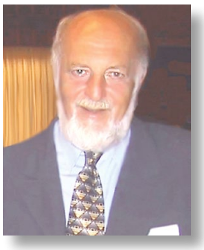
Dr Zdenek Prevorovsky

Biography & Abstract



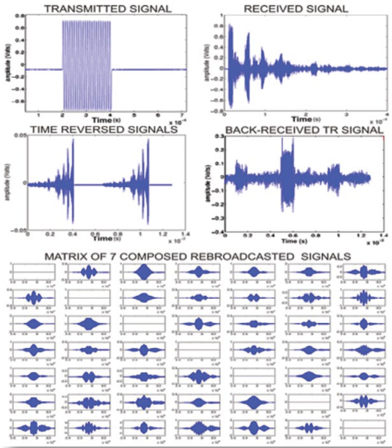
Since his university studies, Dr Prevorovsky has been engaged in the Czech Academy of Science (CAS) in the field of physical and mechanical engineering, specialising in NDT/NDE/NDI and fracture mechanics of materials and structures. His research interests and published papers are mainly oriented on acoustic emission and ultrasonic methodology, including the latest non-linear and time-reversal spectroscopy and tomography, and NDE of all kinds of materials, including biological tissues. His activities in NDT and SHM cover diverse structures, ranging from aircraft to nuclear power plants. Signal analysis, elastic waves and industrial diagnostics with NDT are the main subjects of his university lectures. He is currently with the Institute of Thermomechanics, CAS.

Non-linear ultrasonic time-reversal mirrors in NDT

Dr Zdenek Prevorovsky, Institute of Thermomechanics, CAS, Prague, Czech Republic

Standard ultrasonic NDT methods use for damage detection characteristics of elastic wave propagation – like reflections, time-of-flight, attenuation, spectra, mode conversion etc. Recently developed non-linear elastic wave spectroscopy (NEWS) methods play on local material non-linearity caused by microcracks, bond weakening and corrosion, for example. Observed non-linear (NL) effects provide more sensitive detection and imaging of defects even smaller than the acoustic wavelength used. However, most NEWS methods require structure excitation with relatively large amplitudes. The necessary excitation energy can be substantially reduced combining NEWS with a technique referred to as time reversal mirror (TRM).

The time reversal (TR) procedure consists of forward propagation of waves from the source, which are detected using one or more receivers, and then the recorded signals are reversed in time and rebroadcasted back by receivers inverted to transmit mode. In linear media, interchanging the source and receiver does not change the resulting wave-field (reciprocity principle), which can be used for unknown source reconstruction. If the medium contains a higher order non-linearity, the spatial reciprocity may be broken. The TR process enables to focus the wave energy in time and space on a scatterer (non-linearity) without *a priori* knowledge of its location. TRM enables detection and, in some modifications, also localisation of defects like cracks and other local damages.



The time-reversal procedure

Various NDT techniques based on NL TRM were developed during the last few years and have already been utilised in practice. Different modifications involve, for example, pulse inversion, frequency intermodulation, harmonic filtration, time shifting, decomposition of TR operator (DORT), excitation with symmetry analysis (ESAM) or chirp coding. Piezoelectric transducers are mostly used as both wave transmitters and receivers, and multiplexers switch between modes. Also, the non-contact receiving is realised using laser interferometers or air-coupled transducers. In that case, the reciprocity principle is again applied – an array of transmitters is used as a source of both forward and TR waves. Ultrasonic NL TRM techniques are today under intensive development and are becoming very promising in the NDT and structural health monitoring fields.

Dr Marc Kreutzbruck

Biography & Abstract

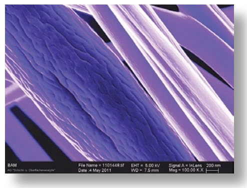
Dr Kreutzbruck received his PhD and the habilitation degree in applied physics from the University of Giessen in 1998 and 2005, respectively. His interests in fundamental research are magnetotransport effects in nanoscale heterostructures, for which he investigated unusual linear and high magnetoresistance effects based on the distribution on the nanoscale. His applied research began in 1995 within the field of superconductivity, where he studied the use of SQUID (Superconducting QUantum Interference Device) as an utmost sensitive magnetic field sensor for non-destructive testing applications, where very deep or small defects could be detected with a SQUID integrated as an eddy current sensor. Later on his research also dealt with the acoustic, thermal or coupled NDT techniques. This also involved signal processing, pattern recognition, and solving the inverse problem to transfer the detected physical properties into the mechanical condition of the component.

Dr Kreutzbruck is now the head of the non-destructive testing division 8.4 at BAM, Berlin, focusing on the acoustic, electromagnetic and thermal methods in non-destructive testing applications. He is member of many NDT-related advisory boards and technical committees and also a lecturer at the Technical University of Berlin.

Nanosensors

Dr Marc Kreutzbruck, BAM Federal Institute for Materials Research and Testing, Division 8.4

Sensors are increasingly pervading many aspects of modern living, such as information technology, transportation, medical devices, automation and safety applications. Usually the miniaturisation trend is motivated to meet the sensor requirements in terms of invisibility and low power consumption. However, entering the nano-world not only offers better sensor integration or the determination of materials properties on the nanoscale, but also opens up the use of a new detection mechanism based on unusual behaviour in terms of quantum mechanical effects at atomic dimensions. In this respect, a nanosensor is a sensing device in which some of its portion operates at the nanoscale, improving its functionality, such as enhanced reactivity, optical absorption or superparamagnetism.



Carbon nanotubes

This talk will provide an introduction into the field of nanosensors, allowing for the detection of a bunch of physical properties such as distances, forces, electronic charges or magnetic fields. The topic will also be highlighted from a NDT-perspective, where nanosensors can already be used or at least have the potential to be used in future NDT applications. Particularly, we draw attention to magnetic nanoscaled thin film devices based on the giant magnetoresistance effect (GMR), consisting of a stack of alternating nm-thick magnetic and non-magnetic layers whose electrical resistance is sensitively influenced by external magnetic fields. Because of their high field sensitivity and their small size down to the sub μm-regime, GMR sensors can support the detection of surface breaking defects in metallic components applying stray field or eddy current testing. As a further example a thermoacoustic device is shown, in which the nm-dimension enables us to generate and to detect airborne ultrasound up to 1 MHz. Carbon nanotubes are driven with an AC-current resulting in a periodic joule heating of the nanowire. Due to its 2D nanodimensions, the heat can be transferred fast enough into the surrounding air to cool the wire within one excitation cycle. The expansion of the heated air then generates the sound wave. This example will show that nanomaterials have the potential to generate strong broadband sound pulses, which are key for future airborne impulse-echo applications.

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