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Young Researchers' Conference

Dates: October 16th -18th, 2018

Location: DNB House Hotel, Via Cavour, 85, 00184, Rome, Italy

Room: Meeting Room "Sala BERLINSANI"

Aim and scope of the meeting:

1) Promoting collaboration and knowledge exchange between PhD students and Young Researchers working on NDT and SHM.

2) Improving the Presentation Skills of PhD students and Young Researchers by planning several sessions of oral presentations of their research activities.

3) providing training through seminars on various specific and complementary topics.

Agenda

Tuesday 16th

9:00 - 9:30	**Welcome Address**
9:30 – 11:00	**Seminar: "Damage detection, imaging and discrimination using nonlinear ultrasonic techniques" and "Evolution of damping and velocity during the very early stages of conditioning and relaxation in diverse media"** **Prof. Antonio Gliozzi, Prof. Mauro Tortello – Polytechnic University of Turin**
11:00 - 11:30	*Coffee break*
11:30 – 12:15	**Seminar: "Monotonicity based tomography"** **Prof. Antonello Tamburrino - University of Cassino**
12:15 -13:00	**Seminar: "Microwave NDE Time Reversal imaging"** **Prof. Lalita Udpa – Michigan State University**
13:00- 14:00	*Small Buffet Lunch*
14:00 – 15:30	**Seminar: "Sensors and signal processing for guided waves NDT and SHM"** **Dr. Luca De Marchi - University of Bologna**
15:30 – 16:00	*Coffee break*
16:00 – 17:30	**Session I – PhD's Presentations**

Wednesday 17th

9:00 – 11:00	**Session II – PhD's Presentations**
11:00 - 11:30	*Coffee break*
11:30 – 13:00	**Seminar: "Convolution, deconvolution and pulse-compression in NDT applications"** **Prof. Marco Ricci - University of Calabria**
13:00- 14:00	*Lunch break*
14:00 – 15:10	**Seminar: "Data acquisition systems and real-time on-board processing"** **Dr. Andrea Cellai - X-Phase s.r.l.**
15:30 – 15:45	*Coffee break*
15:45 – 17:00	**Session III – PhD's Presentations**
17:30-19:30	**Social Event: Guided Tour at Trajan's Market**
20:00	**Social Dinner at Ristorante "Verso Sera"**

Thursday 18th

9:30 – 10:30	**Seminar: "How to write a scientific article"** **Prof. David A. Hutchins -University of Warwick**
10:30 – 11:00	**Concluding Session**
11:00 -11:30	*Coffee break*

Keynote Speakers

Tuesday 16th

Prof. Antonio Gliozzi – Associate Professor, Polytechnic University of Turin

Antonio Gliozzi was born in Turin on October 22, 1973. He graduated in Physics at the University of Turin in March 1998, with a score of 110/110 and a thesis in the field of statistical mechanics entitled "The Phase Transition and the Groundstate Structure of Diluted Spin Glasses ". In the same year, he won a ministerial scholarship at the University of Milan, where he has obtained the Ph.D. in Physics in December 2001, under the supervision of Prof. A. Word and thesis on "Semiclassical Methods for Highly Correlated Electron Systems". In the following year he had a contract for a research collaboration at the National Institute of Physics of Matter (INFM - U.d.R. Como), to continue the studies on high superconductors temperatures. From 2003 to 2011 he carried out his research activity at the Physics Department of the Polytechnic of Turin, with different contractual forms (Research fellowship on PRIN call and EC project, Borsa "Lagrange-Fondazione CRT", Biennial Research Grant within the Region Convention Piedmont-Polytechnic University of Turin). Since 2011 he is University Researcher (scientific sector FIS / 01) at the Polytechnic University of Turin at Department of Applied Science and Technology (DISAT). His research activites at the Polytechnical University of Turin are:

- modeling, experimental validation and analysis of the elastic response (hysteretic) nonlinear ad an external mechanical stress of a material (in particular for integrity prediction mechanical);
- development of nonlinear imaging techniques for the localization of damage in solids;
- Statistical mechanics applied to the microscopic description of the contacts between grains in materials.

He is currently Professor of Physic at Polytechnic University of Turin.

Prof. Mauro Tortello – Associate Professor, Polytechnic University of Turin, Italy

Mauro Tortello is an Assistant Professor at the Politecnico di Torino where he also obtained a PhD degree in Physics. He studied for several years the fundamental properties of novel superconducting materials by the point-contact spectroscopy technique. He also investigated graphene and graphene-based materials by scanning probe techniques, mainly Scanning Thermal Microscopy. He recently joined the group of "Experimental characterization and modeling of electric and elastic properties of linear and nonlinear complex systems". His current research activity mainly concerns the experimental characterization and classification of elastic and viscous properties of solids through the separation of damping and modulus nonlinearities.

Abstract of the Seminar "Damage detection, imaging and discrimination using nonlinear ultrasonic techniques".

Nonlinear ultrasonic techniques are based on exploiting the dependence of some measurable quantities (nonlinear indicators) on the amplitude of the elastic excitation applied to a sample. Since the nonlinearity of the response is extremely sensitive to changes in the microstructure of damaged media, these methods could be used in NonDestructive Testing (NonLinear NDT), with higher efficiency in detecting early damage and potentiality for discriminating different types of imperfections, such as partially closed cracks or incomplete grain crystallization. Different approaches to damage detection, based on the definitions of different nonlinear indicators will be briefly presented: resonance frequency shift, harmonics or sidebands analysis, scaling subtraction method, coda wave interferometry, reverberation, memory. Implementation of nonlinear imaging techniques based on Time Reversal will be briefly outlined. Despite the success of these techniques in lab experiments and the high sensitivity in early damage detection, still their implementation in situ is problematic, due to the intrinsic requirements of the experimental set-up and sensitivity to environmental conditions. Thus, either a simplification of the experimental approaches or focusing the use of NL-NDT to problems which

cannot be solved with a linear analysis is needed. In this direction, a preliminary approach towards the implementation of a technique exploiting memory effects will be presented and the potential of NL-NDT for damage discrimination will be discussed.

➢ Prof. Antonello Tamburrino -University of Cassino, Italy

Antonello Tamburrino (M' 97) received the Laurea degree (*summa cum laude*) in Electronic Engineering from the University of Naples Federico II (Naples, Italy) in 1992, and the Ph.D. degree in Electronic Engineering from the Polytechnic of Turin (Turin, Italy) in 1996.

Since 2006, he has been a Full Professor of Electrical Engineering, Department of Electrical and Information Engineering, University of Cassino and Southern Latium, Cassino, Italy. Since 2014, he has been a Full Professor of Electrical Engineering, College of Engineering, Michigan State University, East Lansing, MI, USA. He has authored or co-authored more than 200 papers that have appeared in refereed international journals, books, and proceedings of international conferences, and is Co-Editor of three proceedings. His current research interests include computational electromagnetism, plasmonics, inverse problems, electromagnetic imaging, and nondestructive evaluation of structures and materials.

Dr. Tamburrino is currently a Subject Editor of the scientific journal NDT & E International and member of the Scientific Board of the journal Nondestructive Testing.

Abstract of the Seminar" Monotonicity based Electromagnetic Imaging"

This talk is devoted to the Electromagnetic Imaging of materials. Electromagnetic Imaging of materials consists in obtaining an image of the interior of a material starting from external measurements of the e.m. field for a prescribed source. Electromagnetic Imaging of materials relies on the capability of e.m. fields to penetrate inside materials. The inverse problem of retrieving/estimating an image of the interior of a material for prescribed sources and measurements, is non-linear and ill-posed. Electromagnetic imaging of materials has been considered in a variety of applications covering different fields such as medical applications, infrastructure monitoring, process tomography, non-destructive testing of aircrafts, gas and oil pipelines, nuclear power plants and railroads.The state of the art of imaging methods in electromagnetism is represented by iterative methods, the drawbacks of which are their high computational cost and the risk of becoming trapped in false solutions (local minima). In this seminar we will discuss the 'Monotonicity Principle Method', a fast non-iterative approach recently developed for elliptic problems (such as electrical resistance tomography), then extended to parabolic problems (such as eddy current tomography) and hyperbolic problems (such as microwave tomography).

➢ Prof. Lalita Udpa - Michigan State University, US

Lalita Udpa is currently a Professor in the department of Electrical and Computer Engineering at Michigan State University. Dr. Udpa works primarily in the broad areas of Nondestructive Evaluation and Signal Processing. Her research interests include development of computational models for the forward problem in NDE, signal and image processing, Pattern Recognition, Data Fusion, and new sensor development for NDE of Composites. Dr. Udpa is a Fellow of the IEEE and the American Society of Nondestructive Testing and serves as an editor of IEEE transactions on Magnetics.

Abstract of the Seminar "Microwave NDE Time Reversal imaging"

Composites are being increasingly used in aerospace, automobile and civil industries, to replace metals, fully or partially, due to their properties of light weight, corrosion resistance and high mechanical strength. The quality and performance of these materials can be severely compromised due to manufacturing or in-service flaws such as disbonds, voids and delaminations. This has propelled research efforts in non-destructive inspection (NDI) techniques for manufacturing and maintenance of composite materials. Microwave NDE techniques offer several advantages in NDE of composites in comparison to other NDE techniques such as ultrasonic, X-ray, visual and thermography. In this talk, we present Microwave NDE for composites in conjunction with model-based Time Reversal processing, a method based on the invariance w.r.t. time-reversal transformations of wave equation. However, a serious challenge in Microwave NDE is diffraction limited

resolution of far field inspection data. In this context, we investigate the feasibility of using metamaterial lens to address this issue. This presentation will first describe some of the work on far field microwave NDE and application of time reversal processing for defect detection. We then focus on the feasibility of designing a metamaterial lens in conjunction with microwave measurements for NDE of composite materials. Specifically, the super resolution capability of the lens for detection of sub wavelength defects inside the composite materials will be studied. Using simulation models, metamaterial lens with specific properties are introduced in a microwave NDE setup and the resulting measurements are processed using model-based time reversal algorithm. Initial results allow detection of source/defects at much higher resolution with the lens.

➢ Dr. Luca De Marchi -University of Bologna, Italy

Luca De Marchi (Assistant Professor at the University of Bologna, Italy) received the Dr.Eng. and Ph.D. degrees in electronic engineering in 2002 and 2006, respectively, from the University of Bologna. At the end of 2002, he joined the Department of Electronics, Computer Sciences and Systems (DEI) at the University of Bologna. Currently, he is also with the Advanced Research Center for Electronic Systems (ARCES). In 2010, he was visiting researcher at the Vibration and Wave Propagation Lab, Georgia Institute of Technology (Atlanta, USA). He is co-recipient of the "Gold Leaf Certificate" at the IEEE International Conference on Ph.D. Research Conference in Electronics and Microelectronics 2005. He has been a member of the technical program committee of several editions of the IEEE International Congress on Image and Signal Processing. His current research interests are in embedded systems and ultrasonic signal analysis for structural health monitoring applications. In this research fields, he holds two patents and he has published more than 100 papers in peer-reviewed international journals and conferences.

Abstract of the Seminar "Sensors and signal processing for guided waves NDT and SHM."

The use of ultrasonic guided waves (GWs) for structural health monitoring (SHM) has interested many researchers. Nevertheless, Lamb-wave testing for SHM is complicated by the dispersive nature of wave modes, which deteriorates the wave spatial resolution and makes the experimental data hard to interpret. To tackle this problem, methods which analyze the dispersive signals in the domain spanned by time-frequency representations (TFRs) have been proposed. An infinite number of TFRs and processing tools can be obtained by using unitary transformations. Unitary operators such as the Warped Frequency Transform (WFT) are particularly suited for the analysis of GWs. This talk will focus on WFT-based analysis methods capable to achieve sparse representations of GW signals. These methods naturally lead to super-resolved and artifact-free representations, even in noisy environments, and are particularly effective to extract the information on the wave distance of propagation. The concept of sparse representations is also the basis of the so-called compressive sensing (CS) theory, which offers an intriguing alternative with respect to the classical process of acquiring signals according to the Shannon–Nyquist paradigm. CS theory proves that a signal which is sparse in a given representation can be compressed directly at the sampling stage. In this talk, a CS framework for Lamb wave field acquisitions with air-coupled probes or laser-Doppler vibrometers will be presented. The proposed framework is intended to minimize the number of ultrasonic scan point locations over the surface of the inspected structure. The implemented procedure is based on the selection of suitable sparsity-promoting TFR domains and on dedicated sample-point distribution strategies, achieving highly effective recovery results while starting from highly incomplete wave-field data.

Wednesday 17th

➢ Prof. Marco Ricci -University of Calabria, Italy

Marco Ricci received the Laurea and Ph.D. degrees from the University of Rome "Sapienza" in 2002 and 2006, respectively. From 2007 to 2016, he was with the Department of Engineering of the University of Perugia as an Assistant Professor. Since 2016, he has been an Associate Professor of electrical engineering with the University of Calabria. He has authored over 80 publications including international journals, conference proceedings, and book chapters in the fields of nondestructive testing and evaluation, signal and image processing, spintronics, and quantum information. His current main research topic is the application of signal and image processing to nondestructive testing. In this field, he coordinated various national and international research and applied research projects.

➢ Dr. Andrea Cellai -X-Phase Srl, Florence, Italy

Andrea Cellai received the PhD degree in Electronic Systems Engineering in 2010 defending a thesis on "Design and realization of a high speed acquisition board for a programmable ecographic system". After two years of Post-doc, he started his current activity as Administrator of X-Phase s.r.l., being one of the founders. He is involved administration, purchasing, electronic design, project management and manufacturing control. Its main interests include high speed board design and use of FPGA devices.

Thursday 18th

➢ Professor David A. Hutchins CEng FREng

School of Engineering, University of Warwick, Coventry CV4 7AL, UK

1. EDUCATION

BSc Combined Honours (1st Class) (1975), University of Aston in Birmingham. PhD in Physics (1978), University of Aston in Birmingham.

2. EMPLOYMENT

1978: Visiting Researcher, H.C. Ørsted Institute, Copenhagen, Denmark: The work involved the detection of point defects in metals, in collaboration with the Danish Welding Institute.

1979: Postdoctoral Research Fellow, University of Hull, UK: Investigation of ultrasonic generation by high-power pulsed lasers in solid materials, for applications in materials testing (sponsored by AEA Technology).

1981: Postdoctoral Research Fellow, Dalhousie University, Nova Scotia, Canada: This was in Mechanical Engineering, funded by a Fellowship from the James Watt

Memorial Foundation. It was used to study acoustic noise control barrier designs for reducing car noise pollution.

1982: NSERC University Research Fellowship (URF) / Assistant Professor, Queen's University, Ontario, Canada: The NSERC URFs were highly-competitive awards, tenable for up to 10 years (similar to the Royal Society scheme in the UK). The post was associated with the Engineering Physics program.

1985: Associate Professor and "Golden Apple" award in 1985 for excellence in the teaching of Engineering.

1988: School of Engineering, University of Warwick.

1988: Lecturer; *1990:* Personal Readership;

1995: Personal Chair (Professor).

1996: Divisional Leader (Head of Department).

2000: Director of Postgraduate Affairs.

2006: Director of MSc programmes.

3. PROFESSIONAL ACTIVITIES

Royal Academy of Engineering: Elected a Fellow of the Royal Academy of Engineering in 2016.

Divisional Leader within the School of Engineering at the University of Warwick: Directly responsible to the Dean of Engineering and the University administration for all aspects of the Division, including:

Staff: Academic, administrative, clerical and technical staff; appraisal, new posts and hiring of new staff.

Finances: All financial aspects of the budget.

Students: All undergraduate students; PhD students; student recruitment; health and safety.

Journals: Associate Editor, IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control

Professional Institutes: Fellow of the IET; Fellow, British Institute of Nondestructive Testing;

Other appointments: Adjunct Professor, Queen's University (Canada); Guest Professor, KU Leuven (Belgium); Visiting Professor, University of Bordeaux (France); Visiting Researcher, Nippon Institute of Technology/Tokyo Institute of Technology.

Chartered Engineer: I am a registered Chartered Engineer through the British Institute of NDT.

4. RESEARCH FUNDING

EPSRC: Continuous EPSRC funding since 1988.

UK Government: TSB programme and DEFRA LINK funding.

Industry: Direct industrial funding from various industries.

Funding levels in last 10 years: > £500k in current grants in any particular year.

EU: Research Networks and Training Networks (ITN).

5. EXAMPLES OF RESEARCH ACTIVITIES WITH INDUSTRIAL LINKS

Below is a selection of research projects that have been performed with industrial collaboration.

1. Non-contact ultrasound research involved work with Alcan Inc and US Steel Canada Inc for on-line inspection of continuously-cast materials such as aluminium and steel.
2. Detection of hydride embrittlement in CANDU reactors was performed with Ontario Hydro Ltd, the aim being to detect defects in pressure tubes that might lead to leakage of the heavy water coolant/moderator Non-contact inspection of titanium nuclear waste disposal canisters was also investigated, to look for potential leaks following diffusion bonding sealing.
3. Characterization of oriented polypropylene polymers, measuring the properties of silicon at high temperatures, and monitoring slip-cast ceramics were all performed with Alcan Ltd .
4. Micro-seismic geophysics for the characterization of rocks, using acoustic emission and tomographic imaging. This minimized the chances of rock bursts and ingress of water.
5. Micromachined silicon capacitance-based ultrasonic devices (CMUTs) have been used with QinetiQ for accurate measurements of very low liquid flow rates, and also for structural health monitoring.
6. Ultrasonic non-contact inspection of food products has been investigated, the aim being to detect contaminants in food whilst on a production line (DEFRA).
7. The monitoring of off-shore wind turbine towers for in-service degradation has been performed as part of a project, with industrial partners including RWE/NPower.

8. Methods for personal security screening for hidden weapons and explosives has been of interest, funded via the Home Office/Metropolitan Police.
9. Acoustic signals have been investigated for screening freight cargo containers remotely at border crossings, for the detection of stowaways and illicit contraband.
10. A new type of short-range digital communication system has been developed [14], based on the innovative use of ultrasound for extremely secure communications within a room (with input from Thales).
11. Instrumentation for a future Mars lander was developed with Cornell and Oxford Universities.
12.Membership of the Research Centre for NDE (RCNDE) has allowed specific targeted research to be carried out with selected industrial sectors.

6. THE CREATION OF NEW COMPANIES

I have been involved in the creation of a number of new start-ups, arising from technology developed during my academic career. Some examples of spin-out companies from the University of Warwick are:

1 *Microcacoustic Instruments Inc* (http://www.microacoustic.com/index.htm) is based in Canada, and uses our patented joint work in micromachined sensors. This company has now been in successful operation for 15 years.
2 *Warwick Audio Technologies Ltd* (www.warwickaudiotech.com/) is developing very thin and flexible loudspeakers (<1mm thick), for use in headphones, noise cancellation etc.

7. PUBLICATIONS

Total publications: 400+ (>200 journal papers, >200 conference papers, 9 book chapters and 4 patents).

35 papers are in the Journal of the Acoustical Society of America – the top journal in Acoustics.

Conference papers include Invited talks at many international conferences (20+), including keynote addresses.