ICNEM '07 - AJACCIO, CORSICA

Sponsors

The Institute of Geophysics & Planetary Physics

Los Alamos National Laboratory

The Acoustical Society of America

Related Documents

Participant List

Images

Please share images with Jeff.

XII International Workshop on Nonlinear Elasticity in Materials

June 3-9, 2007

The 12th International Workshop on Nonlinear Elasticity in Materials will be June 3-9, 2007, in Ajaccio, Corsica (France). The annual wo
group of researchers worldwide to have the opportunity to meet, exchange information, and plan the next year's work. All persons inter
general goals of this workshop are to discuss recent findings regarding the elastic nonlinear behaviour of solids including basic research
applications to nondestructive evaluation of solids, earthquake strong ground motion, earthquake dynamics, medical diagnostic applicat
reversal combined with elastic nonlinearity, and other topics as well.

The workshop is designed to stimulate interactions among researchers in nonlinear elasticity. In the morning sessions, researchers prese

afternoon sessions are aimed at exchanging information, data, and ideas.

Registration - The fee, €170 payable in cash only, will be on the terrace at Hotel Les Mouettes from 17:00-18:00, Sunday June 3. The meeting will be held at the Palais des Congres, Quai l'Herminier in the center of Ajaccio.

Presentation Schedule - The schedule for the conference is available in two formats - as a PDF or a web page. Presentations are to be nc

Abstracts - (Abstracts are listed below.) We are negotiating publication of the abstracts in an international journal and/or by an interna Additionally, abstracts will be compiled and distributed at the conference. Abstracts should be submitted in Word-friendly format by Ma should include a title and a summary of no more than one page.

Lodging & Getting There - We have an entire page dedicated to lodging, reservations, maps, and transportation.
Did you book by March 16th? Also make your workshop reservation. Cancelling later will be much easier than attempting to book a roor you are unsure whether or not you will attend, please book anyway; you may cancel later.

Previous Conferences - In 2006, one afternoon session was dedicated to analysing strategic directions for research in nonlinear elastici and manners to support future collaborations and projects. A dedicated session focused on using nonlinear imaging technique to detect dynamics.

Your participation will be greatly appreciated. If you are not interested, please inform us so that we can remove your e-mail address fron

Yours sincerely,

Michele Meo, University of Bath

Paul Johnson, Los Alamos

Carène S. Larmat, Los Alamos

General Conference Information

The conference will be held at the "Palais des Congres", the convention center, in the heart of Ajaccio.

Reserving a Room

We hope you reserved your room by March 16th. Book now! Canceling later will be much easier than attempting to book a room later.

The hotels are filling up fast. If you are unsure whether or not you will attend, please book anyway; you may cancel later.

We have an agreement with the Chamber of Commerce (Chambre du Commerce) in Ajaccio. We will make our reservations through the to be sure we have no further problems, Carène Larmat will make your reservation for you. Please complete the Hotel Request Form an

A credit card will hold a room with no prepayment. There is no penalty unless you cancel with less than 48 hours before the reservation. contact us. As this is high season, please reserve your room early. Specify that you are attending the International Workshop on Nonline

Lodging

Les Mouettes is the primary hotel, but it is a 20-30 minute walk from the conference center. The hotel is closed until 23 March, but e-ma fifteen rooms, all facing the sea. Add €14 for breakfast. There are five 'Charmes' rooms (20-23m2) at €149 until 8 June then €179/day. E private sun deck are €179 then €219/day. A single 'Junior Suite' (30m2) is available. It has private sun deck and runs €219 then €269/da private sun deck is €259 then €319/day.

The Hotel San Carlu seems to be popular. It has five rooms at €97/day with breakfast. Confirm cancellation policy before reserving.

The Hotel Kalliste is an inexpensive alternative in Ajaccio. Ranking two stars, it is a 19th-century building that has been renovated recen

It is only 2 minutes or so from the Palais de Congres, the middle of Ajaccio. It has five rooms available. The rate is €56 - 94/day, though th by the Palais des Congres. Add €7.5 for daily breakfast in the lobby.

Getting There

It IS possible to fly from Charles de Gaulle (CGD) to Ajaccio on Air France with a layover in Nice or Marseille, but it may be more expensi traverse Paris to get to Orly (ORY) all while dealing with jet lag. As of 13 May, the lowest RT fare available between Paris (both ORY and carriers was $266. Palais des Congres lists more flight information in French.

From Paris - Via Air France

From London - British Airways connects via Nice and Marseilles - Expedia

From Rome - Flights are considerably more expensive. Expedia

There is a shuttle from CDG to Orly that operates 6 AM to 10:30 PM: Line 3 of Les Cars Air France stops at Porte C2, Port B1, and Nivea arrivals level of Orly Ouest (west terminal) as well as Orly Sud (your flight to Ajaccio probably leaves from Orly Ouest). The cost is €16 (a depend on traffic. Allow ample connection time to travel from north of Paris to south of Paris on the beltway (peripherique).

Corsica - General Information

Corsica Net

Welcome to Corsica

Generalized Map of the Region

The Organizer's Choice To Do List*

Thinking of arriving early? The Festival of St. Erasmus begins on June 2 with a procession and blessing of the fishing boats in Ajaccio. This boats will be decorated, fish will be grilled at outdoor stalls, and there will likely be music and fireworks.
In Ajaccio, the Musee Fesch, reported to hold the finest collection of Italian art outside of the Louvre in France, is housed in the former re maternal uncle of Napoleon. From their web site... "The building was constructed at the request of cardinal Fesch, maternal uncle of Nap Arts and Sciences to be set up. Born in Ajaccio in 1763, dying in Rome in 1839, this Prelate bequeathed to his home town more than a th the most important in France after the Louvre as regards Italian painting."

The large prehistoric stone monument site of Filatosa, Corsica's Stonehenge, is a World Heritage Site. This isn't very far from Ajaccio.
A four-hour train ride will take you from Ajaccio to Bastia, crossing the mountain spine and valleys of Corsica. (Timetable - PDF File)
The town of Bonifacio (Wikipedia Images) to the south is worth a visit, even if it is heavily touristed.

The GR 20, the toughest long distance trail in Europe, traverses Corsica diagonally from north to south. It is 180km long with a total vari metres. It can be walked in 15 days. Though the GR20 doesn't require any climbing techniques, a perfect fitness level and confidence in v terrains is necessary. Read more about this and other hikes.

*Thanks to She Who Organizes the Universe

Tourism Links

Virtual Tourist

ICNEM '07 Abstracts

Experimental Study of Ultrasonic Harmonic Properties in Rock and Concrete

Xiaozhou Liu, Xiufen Gong, Jinlin Zhu, Chang Yin

Nonclassical nonlinear acoustic phenomena such as hysteresis and discrete memory are shown in rock and concrete and other mesosco different from classical nonlinear acoustics. In this study, the transmission of fundamental, second and third harmonic changing with the studied in rock. The ultrasonic attenuation was also studied and compared with that in metal. The harmonic properties in concrete were after immersion in water. Qualitative explanation was given for the experimental results. This study is helpful for the study of non-destru elastic materials.

This work is supported by the National Natural Science Foundation of China (No:10674066) and State Key Laboratory of Acoustics.

A Time Reversal Matrix for Nonlinear Elastic Wave Scattering

R. A. Guyer

The effectiveness of time reversal in linear acoustics (TRA) depends importantly on reciprocity of the transfer matrix and hermiticity of t
scattering from a linear elastic scattering structure. When a frequency protocol is introduced into the time reversal procedure, these pr
from a nonlinear elastic scattering structure. Consequently, it is possible to use time reversal methods in nonlinear elastic wave scatteri
used in linear elastic wave scattering. In particular, one can train a many-mirror re-broadcast to focus on the strongest nonlinear scatter
structure, on the second strongest nonlinear scattering feature in a nonlinear scattering structure, etc. Thus dedicated exploration of no

Multiscale Model for Hysteretic Moisture Behavior of Wooden Materials

Dominique Derome, W. Zillig, H. Derluyn, J. Carmeliet

Wooden materials show an important hysteretic behavior in sorption of moisture. To model the hysteretic behavior, a Preisach-Mayergo
distribution is determined from the main adsorption and desorption and additional primary scanning curves. We assume that multilayer
that capillary condensation is hysteretic. The PM model is compared to the Mualem's similarity model for sorption hysteresis where the
by the product of two univariate density functions and only the main adsorption and desorption curve are needed. Furthermore, the hys
network approach using invasion percolation.

The hysteretic behavior is also measured in a dynamic experiment where a wood and book specimen are exposed the changes in relative
water vapor transport in wood, taking into account the cellular structure of wood, is developed. It is shown that when modeling the hyst
permeability is a nonlinear property dependent on the actual degree of saturation. Finally, a two scale model is presented for the sorptio
paper sheets and air layers in between.

Nonlinearity-Based Diagnosis and Localization Techniques for Microdamage Detection

Pierre-Yves Le Bas, Koen Van Den Abeele

Innovative diagnostic techniques based on Nonlinear Elastic Wave Spectroscopy 'NEWS' have been implemented for global inspection o
aeronautical components using low and high frequency sound waves. For low frequency analysis, we focused on the amplitude depende
both in time and frequency domain. Alternatively, we have analyzed the time-windowed interaction of a hammer impact with a high freq
of both techniques agree extremely well and prove their potential for quick and global microdamage detection.

For local inspection, we have implemented a combination of the traditional elastic wave time reversal technique with a phase coded puls
Alternatively, sparse array tomographic reconstruction with NEWS pretreatment could be used. The nonlinearity based imaging technic
components and are discussed in terms of the feasibility and usefulness of the methodologies as new tools for microdamage imaging.

Effect of Water Saturation on the Nonlinear Behaviour of Concrete

Cedric Payan, Vincent Garnier and Joseph Moysan

Nonlinear interaction of a monochromatic elastic wave with a low frequency should be a good tool for non-destructive evaluation of exis technique has already proofed efficient in detecting global damage. However, it is necessary to understand the influence of some structu state, or water saturation on the nonlinear processes. In this way, a thermodynamically based model containing all of them is presented i nonlinear interaction measurements in order to quantify the evolution of the nonlinear behaviour of concrete with water saturation stat

Emergence and Interaction of Solitary Waves in Microstructured Solids

Andrus Salupere, Kert Tamm, and Jüri Engelbrecht

Microstructured materials like alloys, ceramics, functionally graded materials, etc. have gained wide applications in contemporary techn propagation in such materials should be able to take into account various scales of microstructure. The scale-dependence involves dispe therefore solitary waves and solitons can emerge in such materials if these two effects are balanced.

According to Mindlin, a material is interpreted as an elastic continuum including microstructure that could be 'a molecule of a polymer, a a granular material'. This microstructure is modelled by microelements within the macrostructure. Engelbrecht and Pastrone combined wave hierarchies and derived governing equation which takes into account nonlinearities on both macro- and microlevel and dispersion. Engelbrecht-Pastrone model is used for numerical simulation of 1) interactions between solitary waves over long time intervals and 2) e For numerical integration the discrete Fourier transform based pseudospectral method is used. Results are analysed making use of Four quantities. The influence of different material parameters on the character of the solution is discussed. Special attention is paid to the sc

This work is supported by Estonian Science Foundation Grant no 7035 and EU Marie Curie Transfer of Knowledge project MTKD-CT-2004-013909 under FP 6.

Improvement of Nonlinear Elastic Wave Spectroscopy with Time Reversal Acoustics; Numerical and Experimental Approaches

Thomas Goursolle, Jérôme Fortineau, Samuel Callé, Olivier Bou Matar, and Serge Dos Santos

During the last few years, there has been a strong growing interest for nondestructive testing (NDT) methods based on nonlinear elastic been shown that micro-inhomogeneities such as cracks lead to an anomalously high level of nonclassical nonlinearity. The combination o Nonlinear Elastic Wave Spectroscopy (NEWS) techniques has been used as a new tool for local investigation of nonlinearity in complex m focusing in order to generate nonlinear stress (TR-NEWS) or used as a tool for nonlinear source identification (NEWS-TR).

First the concept of NEWS-TR method is numerically discussed. This method, which uses nonlinear analysis as a pre-treatment of time re the defect position the nonlinear components of the TR received signal. A 3D multi-scale Pseudo-Spectral Time Domain algorithm has b nonlinearity is introduced owing to a PM space model based on a multi-scale approach. This wave solver is used in order to demonstrate signal before TR process with a pulse inversion method.

Second, experiments have been done with TR-NEWS method. It consists in increasing locally stress field using properties of linear TR an analysis. Efficiency of parametric interaction, used as nonlinear analysis, is discussed near cracks in sample with simple geometry.

Finally, with the aim to directly detect defect in bulk, an approach including experimental data in numerical algorithm with NEWS-TR me

perspective of possible new NDT technique.

This work is supported by the European Community Sixth Framework Program AERONEWS, FP6-502927.

Exploration of Trabecular Bone Nonlinear Elasticity Using Time of Flight Modulation

Guillaume Renaud, Samuel Calle, Jean-Pierre Remenieras and Marielle Defontaine

Trabecular bone mechanical strength depends on the porosity, the architecture, the bone tissue density and elasticity, and certainly the bone tissue have a typical size of tens to hundreds micrometers. The relationship between crack density and bone mechanical properties propose a method to measure the acoustic nonlinearty of trabecular bone in order to assess the level of micro-damage.

This technique consists in generating in water a long low-frequency (LF) burst (1 to 3 kHz) sampled by short high-frequency (HF) bursts of 40 kHz. The LF and HF waves propagate in perpendicular directions. NL interactions between the HF and LF waves induce a modulation high HF to LF ratio is such that the sample undergoes a quasi-static loading while a HF burst propagates through the medium. As a consequence is proportional to the Time Of Flight Modulation (TOFM). Several levels of the LF pressure are processed (5 to 50 kPa) to better estimate parameters beta and alpha.

The experimental set-up is firstly validated in water and in samples with classical nonlinear elasticity - plexiglas and plastic foam with arc Then in-vitro measurements are conducted on defatted heel bone, in high porosity and low porosity areas. Human trabecular bone can e 100 with LF strains below 0,1% at the trabeculae level. The value of beta increases linearly with the LF pressure amplitude. The hysteret constant in the range of 10-20. At a given sinusoidal LF pressure level, the TOFM-LF pressure relationship exhibits an hysteresis, and hig in tension than in compression. Nevertheless the hysteretic behavior may be the result of bone viscoelasticity. Finally, measurements at discuss the influence of the low frequency on the measurement.

Slow Dynamics at Millisecond Time Scales

Richard Weaver and Oleg Lobkis

At sufficient gain an ultrasonic feedback circuit rings with a 'Larsen' tone that depends on the nonlinear electronics, and also on the acou which it is attached. Because the spectrum of this tone is extraordinarily narrow and stable, it may be measured with high precision. Such monitor the evolution of the effective modulus of mesoscopically elastic bodies (cements and stones) after brief transient loads. In accor the modulus drops after the load, but then recovers in a characteristic manner, like log(t). The present technique, using as it does higher f loads (10 microseconds), extends these studies of slow dynamics to early times of the order of milliseconds. It is found that log(t) behavio investigated, from a couple of msecs to hundreds of seconds.

Can Nonlinear Ultrasound Detect Bone Microdamage In vitro?

M. Muller, TJ. Ulrich, D. Mitton, M. Talmant, P. Johnson, P. Laugier

Bone fragility assessment has been characterized in the past through the measurement of parameters related to bone density and geom
these parameters alone are not sufficient for fracture risk prediction. Other parameters, such as micro-architecture, collagen state and r
relevant parameters, and it is therefore important to assess them non-invasively. This work focuses on micro-damage characterization u

A collection of human radius specimens was progressively damaged in vitro with compressional mechanical fatigue testing. As damage a
nonlinear hysteretic parameter a was measured in the samples using Nonlinear Resonant Ultrasound Spectroscopy. Slope and hysteresis
were obtained during the mechanical testing. Ultrasound velocity was obtained from the linear resonance frequency at each damage ste
significantly with accumulated damage for all tested samples. Such evolution could not be observed with any of the other measured para
load displacement curve, speed of sound). A positive exponential relationship was found between the nonlinear parameter a and the age
that micro-crack density and age were also proved to be linked by an exponential relationship, suggesting that nonlinear parameter a an
same behaviour with age. Using nonlinear acoustics, bone micro-damage could therefore be assessed non-invasively, through the quanti
seems to have a clinical relevance.

Applying the Time Reversal Mirror to locate the Parkfield Earthquakes Sequence

Carene Larmat, Paul Johnson, Lianje Huang, Jean-Paul Montagner, Mathias Fink, Arnaud Tourin

The Time Reversal Mirror (TRM) is a new approach for source location and characterization that we are in the process of developing and
regional scale. The 28 Sep. 2004 Parkfield, CA, earthquake (092804H) is the world's best recorded earthquake to date and thus one of th
its source characteristics are well studied and that there exist high-resolution 3D velocity models for this area (Thurber et al, 2006), this
feasibility of the TRM as well as the assessment of its resolution power. Moreover, the Parkfield event is part of a sequence of M6.0 earth
1966, 2004) with each time a different source rupture history. Comparing the TRM results might prove to be interesting. Finally, events
to be challenging for classical location methods while TRM is known to be robust with small signal-to-noise ratio. Application of the TRM
has already been successful in retrieving information about the rupture process of the 2004 Great Sumatra event (Larmat et al, 2006). In
method in order to be eventually able to work with quite small events. First, we work on data selection using correlation estimates with s
different methods which may allow us to beat the diffraction resolution limit of simple TRM - deconvolution (Larmat et al, 2006) and sym

Two-Scale Modelling of Nonlinearity During Damage Evolution

Jan Carmeliet, S. Mertens, J. Vantomme

Cyclic tensile-compressive tests on quasi-brittle materials show a complex cyclic behaviour; in pre-peak tensile loading, a nonlinear load
post-peak region, strain-softening occurs during damage evolution. When unloading, the load deformation curve is characterized by a st
and a stiffness recovery in compressive loading. In addition, permanent deformations and hysteretic loops are formed which change of s
compressive loading and vice versa. Moreover, the hysteretic loops change form with damage. All these phenomena are related to the pr
in the form of micro-, meso- and macro-cracks. Nonlinear elastic behavior is explained by the opening-closing of initial defects, while stra
attributed to the growth of the micro- and meso-cracks. Permanent deformations can be explained by the misfit of closing cracks and sti
closure of the cracks. Hysteretic behavior is attributed to the opening and the closing of cracks at different stresses. In this paper, a cons
captures all these nonlinear effects. The model is based on a strain decomposition into a classical linear elastic strain and a non-classical
Mayergoyz (PM) model. The non-classical strain is considered as the outcome of a population of hysteretic elements - called hysterons -

by two distribution functions. The PM distribution, described by two populations of hysterons, is dependent on the damage level. The se
high damage levels or when macro-cracks are formed. At low damage levels, the populated PM-space is located near the diagonal. As the
originate, which are located near the diagonal, causing the hysterons to behave less hysteretic. Because the parameters that describe th
damage, it can also be stated that the total effect (or number) of the hysterons increases. It can be observed that the combined model is
observed phenomena that occur during tensile-tensile and tensile-compressive loading, i.e. in the pre-peak region; nonlinear elasticity, h
stiffness reduction, stiffness recovery, permanent deformations, tensile-tensile and tensile-compressive hysteretic loops.

Selective Localisation of Multiple Sources Using Time Reversal Modelling Results

A..S.Gliozzi, M. Scalerandi, B. Anderson, M. Griffa, P. A. Johnson, and T. J. Ulrich

Localisation of multiple sources (spatially separated) is a non-trivial issue when one of them is much larger in amplitude. In such cases, se
by subtracting a reference signal before time reversal, but this generally is not possible when the sources are unknown. Here, we presen
reference signal from time series recorded at a few points located on the surface of the specimen. The procedure is described in details a
Also, we discuss several details to optimise the results of the source selection procedure. Finally, the implementability in real experimen
shown in a following presentation.

A PM Space Model of Irreversible Changes in Materials Subject to Loading

Marco Scalerandi, A. Gliozzi, C. Bruno, A. Antonaci, D. Masera, P. Bocca

The Preisach-Mayergoyz (PM) approach has been widely used to describe hysteresis in different fields. Among these, various types of re
have been successfully modelled inclusing quasi-static, fast and slow dynamics, modulation, and so on. Here, we propose an approach to
treat irreversible phenomena such as fatigue and damage progression. For this purpose, we introduce a multi-level scheme based on nes
mathematical formulation is outlined and a phenomenological application presented.

**Time Reversal Acoustics (TRA) Reconstruction of Symmetric-In-Time Sources In Solid Elastic Specimens - Investigation of the Effects
TRA in Solids**

Michele Griffa, P. A. Johnson, R. A. Guyer, T. J. Ulrich, B. E. Anderson

Time Reversal Acoustics (TRA) techniques for retro-focusing elastic waves onto primary and-or secondary sources in solid media have b
efficient. Different applications have been devised in order to exploit TRA properties for Non-Destructive Evaluation (NDE) purposes, fo
solid plates using Lamb wave propagation modes, for the selective localization of point-like well-resolved rigid scatterers embedded into
scatterers, for imaging defects giving rise to non-classical nonlinear elastic effects as wave mixing, and for the localization of impact sour
systems fort the control of man-machine interfaces. However, most of the basic investigations of the peculiar self retro-focusing propert
tested with solid specimens submerged into water tanks, with the Time Reversal Mirror (TRM_ in the fluid environment. This configurati
purposes, when, in the usual case, the transducers, used both as sources and TR receivers-transmitters, are bonded onto the surface of t
investigated both theoretically and experimentally the effects of finite-dimension transducers, bonded onto solid specimens, on the prop
dimension of transducers imply a loss of information about the forward propagation stage of a TRA experiment, so it might affect the TR

TRA in solids was made by Draeger et al. in 1997 considering a gedanken TRA experiment through a solid specimen submerged into a flu
outside the solid medium itself. The effects of the solid-fluid interface on the TRA procedure was taken into account in that work. Our w
TRM placed directly onto the surface of the solid specimen under investigation containing a limited number of TR channels due to the fi
have used a different basic theoretical approach based on Green_'s function, numerical simulations and validation laboratory ultrasound
support the characterization of TRA in solids for NDE purposes, e.g. for the 3D localization and characterization of defects behaving as r

Non-Destructive Damage Evaluation of Different Parts in Three Industrial Projects

Yulian B. Kin, Krasimir Z. Zahariev, Bernard W. Parsons Eric Roades, Brian Smith, John P. Companik

The paper describes applications of vibro-acoustic methodology for cracking detection and assessment of damage in three industrial pro

1. The purpose of the first project described in this paper is to assess the damage and compare the fatigue properties of different designs
used in geotechnical drilling equipment. The applied non-destructive damage evaluation technique is based on modal analysis and the im
spectroscopy (IRAS) method. The natural frequencies and modal shapes of the part are analyzed to assess crack growth effect and deter
The method allows for fast on-site inspection and structural health monitoring of the parts prior to their assembly for work. A comprehe
for different designs is conducted by finite element analysis (FEA) in ANSYS. A full scale analytical model of the threaded connection is c
the actual character of the 3D problem. For the fatigue analysis the ANSYS (Workbench) software is implemented using both strain-life
results of acoustical measurements and FEA analysis showed a very good correlation.

2. The aim of the second project was to investigate the correlation of acoustical measurements and modal analysis results for the purpos
used in the Ultraformer Reactor's swing lines throughout BP refineries. A section of the MOV-82 provided by Packer Engineering was us
geometry was reverse engineered as a 3D CAD model to the best possible accuracy by using manual instruments to measure the major d
The main idea of the work was to study the effect of cracking location and size on the natural frequencies of vibration of the sample. The
evaluation is that that cracks will modify the stiffness of the structure and may also affect its mass distribution and its damping properties
dynamic response of the system, and generally lead to reduction of its natural frequencies. It was found that for each of the fourteen cra
frequency response depicted by the frequency shifts of the first two hundred modes. The sensitivity of each mode to the introduced crac
of that mode in the cracking area.

The natural frequencies or modes of vibration of the large valve body section were measured using the IRAS method. Approximately 20
recorded in the range of 0-17 kHz. This quantity of modes can be attributed to the complex geometry of the specimen under examinatio
sideband frequencies recorded from the non-linear testing regime. Overall, more than 90 of the frequencies discovered in the sideband
found with the IRAS method, confirming that the sidebands are actually caused by the natural vibration of the part, and not by some oth
the natural frequencies by the IRAS method may discover the remaining modes found by the non-linear method. It is possible that these
power that the initial IRAS method did not detect them, indicating that the non-linear method is more sensitive to damage than linear m

3. The goal of the third described in the paper project is to develop a novel acoustic technology for blast furnace refractory structural he
no methods providing direct structural health monitoring of blast furnace refractory. The objective of this project is to develop an acoust
furnace wall thickness, assess erosion and estimate damage accumulation in the furnace wall. The results of acoustical measurements ca
assessment, CFD optimization, development of blast furnace lifetime prediction model and modification of preventive maintenance.

Ceramic censors were attached to the metal shell of the blast furnace wall and measurement using IRAS method were performed for the instead of sensors the laser vibrometer was also used. Using the results of these measurements the plots representing the change in pro

Support of 21st Century Research and Technology Fund of Indiana, Boart Longyear Company, Environmental Drilling Division and BP Products North America Inc. is gr

Frequency Sweep with Constant Strain Output

Kristian Haller and Claes Hedberg

Slow Dynamics and resonance curves from frequency sweeps show a change of elastic behaviour with different excitation strength. This resonance frequency with increasing excitation strength. To carefully determine material property like elastic modulus, it has been repo output dependence affects the result. Experiments conducted on rock samples comparing the constant excitation strength to constant s constant velocity output and also to constant strain energy output show a less pronounced change in frequency shift with increasing loa internal load is held on constant level and the material properties can be carefully determined.

Time-Reversed Acoustics for Focal Depth Estimation - Application to Local, Shallow Earthquakes in Southern California

Fred Pearce, Rongrong Lu, and Nafi Toksöz

Determining the focal depth of earthquakes is of critical importance to nuclear explosion monitoring and seismic hazard assessment stu depth estimation are typically based on travel times and result in large uncertainties in depth estimation, which are primarily due to poo travel time picks. We propose an alternative method based on an adaptation of time-reversed acoustics. In the context of TRA theory, th recording can be thought of as the convolution of the source autocorrelation function with the autocorrelation of the Green's function d source and receiver. Furthermore, stacking the autocorrelations from many receivers will improve the signal to noise ratio (S-N) of static In this study, we employ such an approach to estimate the focal depth of shallow earthquakes based on the time lag between the direct P (reflection from free-surface), which is assumed to be approximately stationary across the receiver array, i.e. time lag is similar for all rec phases have similar ray paths, the focal depth can be approximated using the measured time lag and the average velocity above the earth may be used to provide an independent estimate of focal depth to reduce uncertainty. We apply this methodology to estimate focal dept obtained in Southern California. Earthquake recordings were obtained from the Southern California Earthquake Center (SCEC) for even estimates of focal depth that are less than 10 km, and magnitudes ranging between Mw 4.0 and 6.0. The 3D velocity model from SCEC w and S-wave velocity above each earthquake. In general, we observe both pP and sS phases in the stacked correlations that correspond to catalog. The predictive capability of the method is limited by S-N, defined as the stacked correlation amplitude corresponding to pP (or s level of the stacked correlation. We examine the sensitivity of the S-N on station location, i.e. epicentral distance (azimuth) by considerin array. We find the S-N ratio is generally better for subsets of receivers within regions of similar geologic structure suggesting our assump ray paths may not be valid in regions with complex subsurface structure such as Southern California. We are currently refining the meth pre-stack analysis method and the two-frequency correlation function.

In Situ Nonlinear Soil Response Applying an Active Source

Fred Pearce, Paul Bodin, Zack Lawrence, Joan Gomberg, Farn-Yuh Menq, and Paul Johnson

It is well known that soil sites have a profound effect on ground motion during large earthquakes. Commonly, the site response of soil sit
soils are measured separately, with the latter frequently obtained via laboratory measurements. Here we describe a new method of mea
large vibrator source, and show that we can characterize nonlinear soil response using measurements obtained immediately adjacent to
wavefield composed of body-wave reverberations between layers and surface waves from their constructive interference that are chara
the nonlinear behavior of the soil by incrementally increasing the source amplitude and monitoring changes in the soil response as a fun
computed between receiver pairs located in a small array adjacent to the source, which help separate near-source nonlinearity from per
Dramatic decreases in the peak frequency of spectral ratios are observed across the array as the source amplitude is increased. Furtherm
we observe depends on their frequency, a proxy for depth, and is consistent with laboratory measurements of soil nonlinearity. Measure
under natural conditions are critical to advancing our understanding of soil behaviour during earthquakes. The experimental protocol ar
developed are directly applicable to numerical modelling codes, thereby providing a method for rigorously benchmarking existing nume
nonlinear soil behaviour. Future work will focus on comparing our field results with several existing numerical models used to predict str
earthquakes.

Nonlinear Dynamics of Stressed Granular Materials Near Acoustic Resonance

Jérôme Laurent, Xiaoping Jia and Paul A. Johnson

Elastic waves propagating through a confined granular medium provide a unique probe of both the structure of the contact network and
between grains, and also to the irreversible rearrangement of grains possibly at large sound amplitude. In this work, we study quantitativ
experiments the non-equilibrium dynamics and the nonlinear elastic behavior of dry granular materials under different effective applied
strain is increased (from 10^-7 to 10^-5) the resonance frequency of either compressional or shear mode decreases and the resonance p
modulus softening (up to 10%) and hysteretic dissipation respectively. Also the granular samples exhibit a slow dynamic recovery of the
hours (aging of contacts). Coupled with the packing density measurement, our nonlinear acoustic experiments offer a very helpful metho
the unjammed state of weakly confined granular media and also to understand the physical origin of dynamic triggering of the fault core

Nonlinear Resonant Ultrasound Spectroscopy Studies of Nanocrystalline Nickel Alloys

Tarik Saleh, J. A. Tencate, TJ Ulrich and P. A. Johnson

Nanocrystalline alloys are currently in the forefront of materials research. They display a range of beneficial materials properties compa
As a part of a comprehensive characterization of nanocrystalline nickel alloys, the nonlinear behavior of the alloys was explored using no
spectroscopy. Nickel-iron alloys with grain size of 25 nm were used in this study. Various nickel based superalloys were used as linear co
This talk will cover the theoretical basis of the performance benefits and the nonlinear behavior in nanocrystalline alloys. Additionally a
nanocrystalline and conventional nickel alloys will be presented, along with experimental challenges encountered enroute.

A FFT-Based Full-Field Model for the Study of the Elastic Properties of Rocks

D. Pasqualini and R. A. Lebensohn

We applied an efficient full-field formulation based on Fast Fourier Transforms (FFT) for the prediction of the elastic deformation of poly properties of geomaterials. In this model the rock is described by a unit cell, which represents an aggregate of single crystal grains with p by outer layers of percolating grain boundary regions. Constructed the initial unit cell from a real microstructure, this method provides a equations and has better numerical performance than a finite element calculation for the same purpose and resolution. This method allo size, porosity, strain rate and pressure on local and effective behavior of geomaterials. In this contribution, we will present some prelimin elastic response of Fontainebleau sandstone under a standard quasi-static stress protocol.

End Point Memory Revisited

James A. TenCate and Kevin E. Claytor

Perhaps one of the most unusual characteristics of many rocks is the presence of end point memory in stress-strain cyclic loop measurer referred to as return point memory, discrete memory, or relay hysteresis.) The effect can be quite challenging to observe in rocks and ha handful of publications. One unique aspect of end point memory, for example, is that the local slope of a small inner hysteresis loop will c the main (larger) hysteresis loop. Solid qualititative evidence for end point memory didn't exist until Boitnott (1993), Hilbert et al. (1994) data are perhaps the first and are also the cleanest evidence that can be presently found. Unfortunately, even the best existing data are n used, to our knowledge, were all hydraulic. Many load frames readily available today (e.g., Instron) are mechanical, screw driven types. Er difficult to observe, and there are still aspects of end point memory that have not been explored or carefully measured. While setting up worth re-examining and making some new measurements of end point memory. Mechanical or screw type load frames of the sort more c inherent hystersis; they can even show end-point-memory-like behavior (Norton, 2004). However, the benefits of the new systems and a and the ability to take and store data at a density unavailable to earlier researchers begs more careful experimentation. There also are fe have not been measured carefully or reported, e.g., congruence. That in itself makes it worth making another set of measurements of thi more quantitative approach using much larger data densities than before and looking at aspects of end point memory that have not beer

Work supported in part by the 21st Century Research and Technology Fund of Indiana on which LANL is a subcontractor to Purdue, Calumet

Sound Propagation and Force Chains in Photoelastic Granular Materials

Karen E. Daniels and Clifford E. Chafin

One prominent feature of granular materials is the highly nonuniform distribution of internal forces, in which a small fraction of the part force, arranged in roughly colinear structures. To understand which signatures of this 'force chain' network are present in acoustic signa arrays of photoelastic particles and examine the spatio-temporal dynamics due to sound waves. Because a photoelastic disk viewed thro brightness pattern indicative of its stress state, such aggregations allow measurement of the forces and positions for all particles. In our 200 microsecond square wave pulses through granular packings, and make optical measurements of the changes in the force chain netw Simultaneously, we use biaxial accelerometers of similar size and mass to the photoelastic particles to provide the amplitude and speed o force chain network. We find that the signals parallel and perpendicular to the direction of the driver motion differ in their speed, amplit faster-stronger signals occurring along stronger force chains.

The Effect of Acoustic Waves on Stick-Slip Behaviour in Sheared Granular Media

Paul A. Johnson, Heather Savage, Matt Knuth, Joan Gomberg, and Chris Marone

Dynamic earthquake triggering remains a compelling mystery: how do transient seismic waves with strains of order 10-6 trigger earthqu
long after the waves have passed? To better understand the physics of dynamic triggering, we conducted laboratory studies of stick-slip
applied acoustic waves. Glass beads were used to simulate granular fault zone wear material, sheared in a double-direct configuration u
subject to transient or continuous perturbation by acoustic waves. Here we show that small magnitude failure events, corresponding to
bead layers, occur when applied sound-wave amplitudes exceed several microstrain. These events frequently occur as part of a cascade
acoustic waves also cause large slip events to be delayed significantly relative to those observed without wave perturbation. Remarkabl
major-event cycles after the termination of the acoustic signal, indicating a strain memory in the granular material despite the severe ma
large stick-slip event.

Faster and Reliable Topology Optimisation Using Smooth Boundary Representation

H. Alicia Kim

Topology optimisation is considered the most general hence perhaps most versatile form of structural optimisation. A use of topology op
remodelling mechanism is presented to demonstrate the range of potential applications. However the finite elements in the formulation
to a non-convex problem. A number of numerical techniques such as power-law penalisation and continuation method are thus common
convexity. We find however that the solutions can be highly sensitive to the implementation of the numerical techniques and may lead to
simple problem. This sub-optimal solution may be a local optimum that is inherent to the problem or may be an artificial local optimum c

Following on from the study, we develop a more continuous approach to topology optimisation by applying the fixed grid approach to the
representation of a structure allows non-homogeneous elements and therefore the design variables are no longer binary existence of ar
the boundary. This eliminates the need for the numerical techniques mentioned above and improves the reliability and stability of the op
benefit of this approach is that it is well suited for iterative modification of the structure, significantly improving the computational cost.

Phenomenological Universalities as a Tool for Experimental Research

Pier Paolo Delsanto

Phenomenological Universalities (PUN) may be defined as the "Inbegriff" of a given body of phenomenology, i. e. what remains of it once
application is completely disregarded. As such, they can be very useful in providing a cross-fertilization among different fields (ranging fr
biomedical and social sciences). Two PUN's have recently been proposed for the analysis of growth problems [1] and of nonclassical non
classification scheme has been devised, which seems to account for all the growth models which have been proposed up to date. As an ap
elastic response to temperature of consolidated granular media [3] has been performed, showing that, after an abrupt temperature char
Q-value of the specimen vary with time according to the predictions of one of the classes (U2) of the considered PUN. The analysis also a
of the experimental results and to suggest new experiments to be performed. Other applications of the PUN's will also be presented and

1. P. Castorina, P.P. Delsanto and C. Guiot , Phys. Rev. Lett. 96, 188701(2006); 2. P.P. Delsanto, editor: "Universality of Nonclassical Nonlinearity, with Applications to N

Delsanto and S. Hirsekorn, ibid. Chapter #1, (2007); 4. T.J. Ulrich, in "Innovations in Nonlinear Acoustics, 17th Int. Symp.", edited by A.A. Atchley et al.. A.I.P. (2006), p.27

Localization of Defects in Complex Structures by Nonlinear Wave Modulation and Time Reversal

Zdenek Prevorovsky

Nonlinear Elastic Wave Spectroscopy (NEWS) is very effective non-destructive testing method providing high sensitivity in incipient dar of this methodology consists in the ability to detect small defects relatively far from ultrasonic actuators and sensors located on complex NEWS procedures - frequency mixing (NWMS) and time reversal (NLTRA) - were applied to reveal fatigue-induced cracks in the aircraft sheets of 1.2mm thickness with riveted stringers and rib). Various configurations of piezoelectric transducer arrays were spaced on teste damaged panels subjected to fatigue testing were compared with that on intact ones. Defect occurrence causes nonlinear effects change procedure, we used two actuators and four sensors. First, 'pumping' actuator was excited by lower frequency (50 kHz) higher power sinu amplitude. Second, 'probing' actuator, was excited by higher frequency (500 - 600 kHz) sinusoidal signal with constant amplitude. Nonlin frequency spectra as inter-modulation side bands and growing odd harmonics. In NLTRA procedure, we used array of symmetrically spa transmitters and six receivers. Propagating elastic wave field, detected by the receiving array, was recorded, reversed in time and irradia source. In linear case, the irradiated field is focused back on the source and partially reconstructed. In media with nonlinearities, caused are concentrated around those nonlinearities and signal self-reconstruction is corrupted. Both procedures are mostly global in their sim less only presence of defects without their localization. An attempt to localize fatigue cracks in damaged wing skin panels has been done parameters, evaluated on different wave paths (pseudo-tomography). High-voltage multiplexer was used to switch between transmitter array. Directional dependence of evaluated nonlinearity parameters helped us to allocate zones with fatigue cracks or other nonlineariti

Failure in Material Under Dynamic Loadings (Bird-Strike)

Michele Meo

(Abstract coming soon.)

ICNEM '07 IMAGES