PHYSICS DEPARTMENT *NUMBER 19, SPRING 2016*

FENOMEN

NEWSLETTER OF THE PHYSICS DEPARTMENT, UNIVERSITAT POLITÈCNICA DE CATALUNYA

NEWS

EVENTS

"Annual Research Meeting of DFIS", January 29th 2016, Institut d'Estudis Catalans, Barcelona. **Organizers:** E. Guàrdia, D. Calvete

"European GdR Dynamo Meeting", June 27th – July 1st 2016, UPC - Barcelona. **Organizers:** F. Garcia, M. Net, J. Sánchez Umbría
http://mhd.ens.fr/GDRE/GDRE2016/

POSITIONS AND AWARDS

Javier Díez was nominated Commissioner of the Spanish Nuclear Safety Council for the next 6 years. During this period he will be on leave from the UPC and his new contact is: javier.dies@csn.es

Cristina Masoller has received the ICREA Academia 2015 award and has been nominated as Optical Society of America (OSA) fellow 2016.

NEW GRANTED PROJECTS

"Morfodinámica de costas: interacción de patrones en diferentes escalas" CTM2015-66225-C2-1-P (2016-2018).
IP: Albert Falqués
Partners: UPC, ICM-CSIC Barcelona, Institut Mediterrani d'Estudis Avançats.

"Desenvolupament i aplicació de models de miòcits auriculars per investigar mecanismes que confereixen pacients un risc alt de fibril·lació auricular" – Maraton TV3 for heart disease
IP: Blas Echebarria

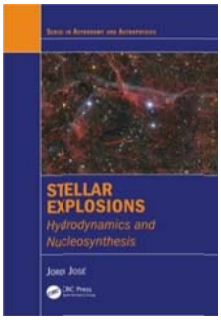
"Atomistic simulation of hydrated and nanoconfined systems, molecular liquids and molten salts" FIS2015-66879-C2-1-P, Proyectos I+D Excelencia 2015, MINECO
IP: Elvira Guardia

"Light and sound waves in crystals, structured media and metamaterials" FIS2015_65998_C2-1-P, Proyectos I+D Excelencia 2015, MINECO.
IPs: Kestutis Staliunas & Jose Trull
Coordinated Proj. with UPV, Valencia.

"Assessment of Performance in current ATM operations and of new Concepts of operations for its Holistic Enhancement" (APACHE)
SESAR Joint Undertaking and European Comission (H2020)
IP: Xavier Prats

RECENT PUBLICATIONS

Jordi Jose (GAA) published the book **"Stellar explosions: Hydrodynamics and Nucleosyntesis"** edited by CRC/Taylor & Francis Press, 2015.



This book is a recent account of stellar pyrotechnics (e.g., classical novae, type I and II supernovae, X-ray bursts and superbursts, stellar mergers) from a multidisciplinary perspective, at the crossroads of computational astrophysics, observational astronomy, cosmochemistry and nuclear physics.

Condensed matter

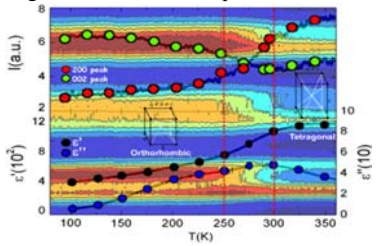
Intermittent aging dynamics in glasses

E. Pineda (GCM) in collaboration with colleagues from the Tech. Univ. of Munich, ESRF-The European Synchrotron and from Univ. of Saarland developed a study where the dynamics of metallic glasses were explored at the microscopic scale by coherent X-ray spectroscopy and macroscopically by dynamo-mechanical analysis. Contrary to the expected steady slowing down of the dynamics during physical aging, this work shows that structural relaxations involved in the aging process are intermittent and highly heterogeneous. This result reflects a very complex energy landscape below the glass transition and a distinctive type of glass dynamics. (***Phys. Rev. Lett. 115, 2015***).

Materials Science

Polymorphic phase boundaries in piezoelectric materials

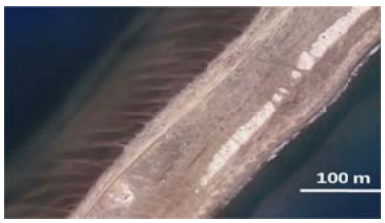
Polymorphic phase boundaries (PPB) in piezoelectric materials have attracted recently a significant interest, in particular because of their unique properties. The electromechanical properties of materials are usually divided in intrinsic and extrinsic. Although it is widely known that certain intrinsic properties of piezoelectric materials increase as PPBs are approached, ***D.A. Ochoa*** and ***J.E. Garcia*** (CEMAD), in collaboration with the Ceramic and Glass Institute in Madrid and the North Caroline State University in USA, have shown that the extrinsic contribution also maximizes. This work demonstrates that the extrinsic contribution at a PPB may have a dynamic role in piezoelectric materials, thereby exerting a far greater influence on their functional properties than that considered to date. (***Appl. Phys. Lett. 108, 142901, 2016***).



Geophysics

Does someone know what has caused this intriguing pattern at the Trabucador beach (Ebro delta)?

This is an aerial orthophoto of the Trabucador beach, in the southern spit of Ebro delta (Institut Cartogràfic i Geològic de Catalunya).

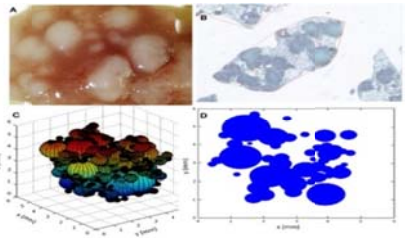


This beach is a barrier facing the Mediterranean Sea to the East (right side) and the Alfacs bay to the West (left side). Along the West coast a complex and very intriguing pattern made of sand bars and troughs can be seen. Typical horizontal and vertical length scales are of tens of meters and tens of cm, respectively. These patterns have been there at least for the last 70 years: they appear, evolve, disappear and they come back again. ***F. Ribas***, ***A. Falqués*** and ***D. Calvete*** from the Coastal Morphodynamics Team (DF) together with researchers from Netherlands, U.K. and Santander, investigates the dynamics of beach morphology, including this sort of patterns. Although some progress has been reached in understanding the self-organized coastal morphological patterns, this case of the Trabucador beach still remains an enigma and nobody knows its driving mechanisms. (***Reviews of Geophysics 53, 2015***).

Biophysics

Mathematical approaches to better understand and tackle tuberculosis

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis* bacillus, that affects the lungs and causes the highest number of deaths worldwide after AIDS. ***C. Prats***, ***D. López*** and ***J. Valls*** (BIOCOM-SC) have developed 3 different computational agent-based models at different spatio-temporal levels. (i) First one, describing the granuloma formation, shows the key effect of the breathing amplitude on the lesion's morphology. (ii) At pulmonary level, a study of the lesion's growth dynamics and proliferation revealed that the coalescence between them is an essential process for an active disease developing.



(iii) Finally, at the epidemiological level, a model for the TB spreading within a closed community allowed the exploration of population heterogeneity effects on the epidemiological TB dynamics in a city. (series of 3 papers ***"Mathematical approaches to better understand & tackle tuberculosis" Frontiers in Microbiology, 2016***).

Astrophysics

Coriolis force in the Universe

The largest Coriolis force in the Universe may be at work in rotating white-dwarfs at the verge of a thermonuclear explosion, giving rise to a Type Ia Supernova. Numerical simulations carried out by **D. García-Senz** (GAA) in collaboration with the Univ. of Basel, show that even for moderate spinning velocities, the Coriolis acceleration acting on a piece of matter in nuclear combustion can be as high as $a_{Col} \sim 2*10^8$ cm/s^2, taking over to the outcome of the explosion. ***(The Astrophysical Journal 819, 2016).***

First direct detection of Gravitational Waves

General Relativity (GR), discovered by A. Einstein in 1915, is the relativistic theory of gravitational interaction that provides a unified description of gravity as a geometric property of space and time. The geometry is defined by a "metric tensor" satisfying Einstein's field equations, relating gravity's sources with a 2nd order differential system for metric components. This theory passed many strict tests over the years. Curiously, one year after its discovery, Einstein realized that GR theory dictates the existence of "Gravitational Waves" (GW). However, the experimental proof of this old prediction has not been possible until very recently.

To conjecture the GW existence, Einstein starts from the fact that, for very small gravitational fields, the metric tensor can be treated as the sum of Minkowski's metric and a perturbation. Considering Einstein's eqs. on such a metric, he got that the perturbations behave as waves (GW) propagating in the space-time at light speed. GWs produced within the Solar system are too weak to be observed with our current technology. However, intense GWs are generated by some phenomena in the Universe where very strong gravitational fields are involved, such as the merging of two black holes. The signature on the GWs of such events can be obtained by numerically solving Einstein's equations.

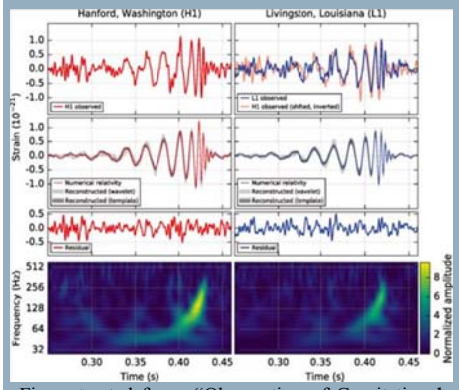


Fig. extracted from: "Observation of Gravitational Waves from a Binary Black Hole Merger" B. P. Abbott et al., *Phys. Rev. Lett.* 116, 061102, 2016.

The detection of GW is not an easy task since, after a long travel through space, these waves produce very small effects when acting on matter. Along the years, some detectors were designed so that strains in space due to an incident GW would excite a solid's resonant frequency and could, thus, be amplified to detectable levels (e.g., resonant cylindrical antenna [Weber, 1951] or resonant spherical detectors [Forward, 1971]). Other detectors were designed to measure changes in the distance between the mirrors of a Laser interferometer induced by a passing GW (LISA& LIGO projects).

The success on the detection of GW has finally arrived with the 2nd generation of LIGO detectors. As explained in the paper "Observation of Gravitational Waves from a Binary Black Hole" (DOI: 10.1103/PhysRevLett.116061102):"On September 14, 2015 at 09:50:45 UTC the two detectors of the Laser Interferometer Gravitational Wave Observatory simultaneously observed a transient gravitational-wave signal. The signal sweeps upwards in frequency from 35 to 250 Hz with a peak GW strain of $\times 10^{-21}$. It matches the waveform predicted by general relativity for the inspiral and merger of a pair of black holes and the ring down of the resulting single black hole. …. In the source frame, the initial black hole masses are 36_{-4}^{+5} $M_\odot$ and 29_{-4}^{+4} $M_\odot$, and the final black hole mass is 62_{-4}^{+4} $M_\odot$, with $3.0_{-0.5}^{+0.5}$ $M_\odot$ c^2 radiated in gravitational waves". ("$M_\odot$" is the Solar mass). These observations are very important for several reasons: they demonstrate the existence of binary stellar-mass black hole systems, they are the first observation of a binary black hole merger and they constitute the first direct detection of the GW predicted by General Relativity. Finally, they have also inaugurated a new era of GW astronomy, which will enable observations of violent astrophysical events that were not previously possible to observe.

F. Fayos & R. Torres

PhD THESIS

- **Jing Yang** "Ion Binding Landscapes and Molecular Dynamics of Phospholipid Membranes".
  Supervisor: J. Martí (December 2015)
- **Israel Cabeza de Vaca** "Mapping biophysics through enhanced Monte Carlo techniques."
  Supervisors: V. Guallar and M. Canales (December 2015)
- **Àngels Fernández** "On Cross-shore Beach Profile Morphodynamics"
  Supervisors: D. Calvete and A. Flaques (December 2015)
- **Jose António Escartín** "ISFAA:Implicit SPH for astrophysical apllications".
  Supervisors: D. Garcia and E. Bravo (January 2016).
- **Antonia Morales** "Observation and interpretation of type IIB supernova explosions"
  Supervisors: J. Issern, E. de la Rosa, N. del Carmen and E. Bravo (Marzo 2016).
- **Amani Tahat** "Computer Simulation of an Excess Proton in Aqueous Systems"
  Supervisor: J. Martí (June 2016)
- **Alessandro Barardi** "Spatiotemporal Coordination of Collective Activity in Neuronal Ensembles".
  Supervisors: J. Garcia and A. Pons (June 2016)
- **Jose Carlos Rivas** "Development of AINA code for the study of loss of plasma control events in ITER and DEMO, and contribution to the systems study of DEMO"
  Supervisor: J. Dies (Febrero 2016)
- **Alberto Riego** "Design of the BELEN detector for wide energy range with flat and high detection efficiency"
  Supervisor: G. Cortes (Mayo 2016)

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