

# FENOMEN

NEWSLETTER OF THE DEPARTMENT OF PHYSICS AND NUCLEAR ENGINEERING

## NEWS

### FELLOWSHIPS

- PhD fellowship on "Stochasticity in nonlinear complex systems". **Contact:** J. Garcia Ojalvo (DONLL) ([jordi.g.ojalvo@upc.edu](mailto:jordi.g.ojalvo@upc.edu)).

- Marie Curie PhD fellowship on "Neuro-inspired photonic devices". **Contact:** C. Masoller (DONLL) ([cristina.masoller@upc.edu](mailto:cristina.masoller@upc.edu))

### EVENTS

- "Physics of complex systems", XXXIV Biannual Meeting of the Royal Spanish Society of Physics, 17<sup>th</sup>-18<sup>th</sup> of July 2013, Valencia. **Organizer:** Prof. J. Garcia Ojalvo (DONLL) (<http://www.bienalfisica2013.com>).

- "11<sup>th</sup> International Symposium on Fusion Nuclear Technology", 16<sup>th</sup>-20<sup>th</sup> of September 2013, Barcelona. **Co-organizer:** Prof. J. Dies (NERG) (<http://www.isfnt-11.org/>).

- "7<sup>th</sup> International Discussion Meeting on Relaxations in Complex Systems", 21<sup>st</sup>-26<sup>th</sup> of July 2013, UPC, Barcelona. **Co-organizers:** Prof. J. L. Tamarit (GCM) (<https://idmrcs7.upc.edu/>).

- "The Origin of Cosmic Elements: Past and Present Achievements, Future Challenges", 12<sup>th</sup>-15<sup>th</sup> of June 2013, UPC, Barcelona. **Chair:** Prof. J. José (GAA) (<http://www.fen.upc.edu/users/jjose/Conf2.html>).

- "School on Fundamentals and Applications of Nonlinear Dynamics", 25<sup>th</sup> of November – 5<sup>th</sup> of December, 2013, Sao Paulo, Brazil. **Co-organizer:** Dr. C. Masoller (DONLL)

### NEW RESEARCH PROJECTS

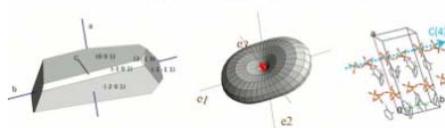
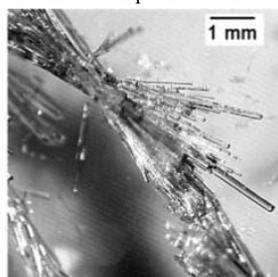
- "Análisis de datos basados en aprendizaje automático y sistemas inteligentes de adquisición de datos: modelos avanzados para entornos de fusión" (INTELLECT) (PI: Manuel Moreno – SARTI), Ministerio de Economía y Competitividad.

## RECENT PUBLICATIONS

### Materials science

#### Shrinking while heating

3,4-Diaminopyridine Dihydrogen Phosphate is an active pharmaceutical ingredient for the treatment of Lambert–Eaton myasthenic syndrome. M. Barrio and J.L. Tamarit (GCM), together with a team of researchers from France and the "l'Assistance Publique-Hôpitaux de Paris", contributed to the development of this drug with a solid-state studies on this compound. The thermal



expansion study has led to a new case of uniaxial negative thermal expansion, which so far has appeared to be very rare. The strongest thermal expansion coincides with an infinite hydrogen bonded chain of anions running parallel to the main axis of the crystalline rods. The negative thermal expansion is observed along an interchanging chain of anions and cations perpendicular to the main axis of the crystals. (*Crystal Growth and Design*, December 2012).

### Laser dynamics

#### Inferring order in complex systems

In a recent paper A. Aragonese, C. Torrent and C. Masoller (DONLL) in collaboration with J. Tiana from the TSC Department and N. Rubido from University of Aberdeen proposed a novel method to infer signatures of determinism in the experimentally recorded sequence of spikes emitted by a laser with feedback. The method uses ordinal

time-series analysis to classify the spikes in two categories that display statistically significant differences. Despite the apparent randomness of the spike events, one category is consistent with stochastic processes while the other presents clear signatures of determinism. This method could be a powerful tool for inferring signatures of determinism in the activity of dynamical complex systems in noisy environments, such as neuronal spikes, earthquakes and human activity in social networks. (*Nature Scientific Reports* 3, 2013 <http://goo.gl/bdGUL>).

### Science & technology of the art

#### Shades of green in 15<sup>th</sup> century paintings

T. Pradell (GCM) together with an international team of researchers has analyzed a 15<sup>th</sup> century selection of green paintings from Catalonia and Aragon Crown using a combination of Synchrotron Radiation micro-analytical techniques including FTIR, XRD and XRF. The green pigments are found to be a mixture of  $[\text{Cu}(\text{CH}_3\text{COO})_2]_x[\text{Cu}(\text{OH})_2]_y \cdot n\text{H}_2\text{O}$  compounds including, in some cases, the presence of  $[\text{CuCl}_2]_x[\text{Cu}(\text{OH})_2]_y \cdot n\text{H}_2\text{O}$  compounds.

Nevertheless, a broader range of green shades were obtained



by mixing the green pigment with yellow, white and blue pigments and applied forming a sequence of micrometric layers. Besides the nature of the pigments themselves, degradation and reaction products, such as carboxylates, formates and oxalates were also identified. The high resolution, high brilliance and small footprint of synchrotron radiation proved to be essential for the analysis of those submillimetric paint layers made of a large variety of compounds heterogeneous in nature and distribution and present in extremely low concentrations. (*Applied Physics A* 111, 2012).

## Astrophysics

### Is $\gamma$ -Ray emission from Novae affected by interference effects?

An international team of researchers, with participation of GAA members A. Parikh, R. Longland and J. José, has shed new light on the uncertain nuclear reaction  $^{18}\text{F}(p, \alpha)$ , which plays a key role in the predicted gamma-ray signals accompanying classical nova explosions. (*Physical Review Letters* 110, 2013).

### Hydrodynamic Simulations

The method known as Smoothed Particle Hydrodynamics (SPH) is a powerful lagrangian mesh-free scheme widely used in many fields of physics and engineering. In two recent papers Domingo García-Senz and José A. Escartín (GAA) together with Rubén Cabezón (University of Basel) have developed and tested a new formalism to compute gradients with better accuracy within the framework of SPH. (*Astronomy & Astrophysics* 538 and 545, 2012).

## Quantum statistics

### One dimension quantum dipolar gases

Quantum one-dimensional systems are very special in terms of statistics. A Bose gas with an infinite repulsion (Tonks-Girardeau gas) has exactly the same energy as an ideal Fermi gas (M. Girardeau, 1960). In a recent article M. Girardeau (University of Arizona) and G. E. Astrakharchik (SIMCOM) one-dimensional dipolar gases are studied for repulsive and attractive interactions (*Physical Review Letters* 109, 2012).

## OUR PEOPLE

### Jordi Freixa, physicist

The story of nuclear power is twofold: on one hand, there is the the fission of atom nuclei that lead to a sustained chain reaction. On the other hand, nuclear engineering must provide the knowledge on how to safely remove the extraordinary amount of energy generated in a nuclear reactor core. This paralel story deals with multi-phase flows and heat transfer processes.



After 11 years of working in the field of nuclear safety, my passion for the science of multi-phase flows led me to join the nuclear thermal hydraulics group (GET, part of GREENER) at FEN.

My research is focused on the computational simulation of nuclear power plants, from the nucleate boiling phenomenon to the activation of safety measures. My studies are those of a multi-scale nature: they combine the study of small water droplets, liquid films around power rods and steam bubbles with the analysis of the behavior of the entire nuclear system. The final goal is to provide a means to understand and safely operate nuclear reactors.

*Jordi Freixa obtained his PhD in Nuclear Engineering from the Technical University of Catalonia in 2007. After a 5-year postdoc at the Paul Scherrer Institut (Switzerland) he joined FEN in January 2013 under a UPC-PQScontract."*

## SIDE NOTE

### Complex light makes things simpler

Semiconductor lasers are ubiquitous and versatile tools in today's life, having fueled for instance the IT revolution through their crucial role in photonic communication systems. However, one of the properties of semiconductor lasers has always been considered a nuisance: they are very sensitive to external perturbations, often reacting to them with fast erratic light pulsations. This complex, chaotic emission emerges because of two reasons: the lasers are inherently non-linear and the coupling (communication) of lasers via their propagating light requires a certain time, resulting in delays. In an article published in *Reviews of Modern Physics* in March 2013, Jordi Garcia-Ojalvo and colleagues from the Institute for Cross-Disciplinary Physics and Complex Systems (Palma de Mallorca) provide an overview of how this curse can be turned into a blessing. Delay-coupled semiconductor lasers and their complex emission are starting to be used for novel applications including encrypted chaotic communication, classical key exchange, sensing, random number generation and photonic information processing. A new perspective is arising from these studies, according to which a whole infrastructure of applications could be developed that might contribute to solving major issues in today's communication and IT systems, including privacy, computational efficiency, and power consumption. In that way, a new paradigm of functional complex photonics is emerging.

## POSITIONS & AWARDS

Prof. Javier Dies was elected Vice President of the European Nuclear Education Network (ENEN). The mission of this association of 64 institutions is the preservation and further development of expertise in the nuclear fields by higher education and training.

## PhD THESIS

- **Manel Martínez Cid** "Evaluación de procedimientos desde la perspectiva probabilística para la seguridad nuclear. Aplicación a un reactor Westinghouse PWR", Supervisors: J. Díez and C. Tapia.

- **Oleg Osychenko** "Monte Carlo study of quantum phase transitions at zero temperature", Supervisors: J. Boronat and G. Astrakharchik, December 20<sup>th</sup> 2012.
- **Lorena Espinar Calvo** "Dinámica de circuitos de regulación genética en bacterias", Supervisor: J. Garcia Ojalvo, June 6<sup>th</sup> 2012.
- **Eduardo Marín Lacomá** "Design and higher order optimization of final focus system for linear colliders", Supervisors: Y. Koubychine and R. Tomás, December 21<sup>st</sup> 2012.
- **Mercè Beltran Vilagrasa** "Impacte dels canvis anatòmics sobre la distribució de dosi en els pacients amb càncer de cap i coll tractats amb 3DCRT i IMRT", Supervisors: M.

Ginjaume and J. Giral

- **Marisol Monterrubio Velasco** "Análisis estadístico y comportamiento fractal de las réplicas sísmicas del sur de California", Supervisors: D. Martínez and F. J. Lana.

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