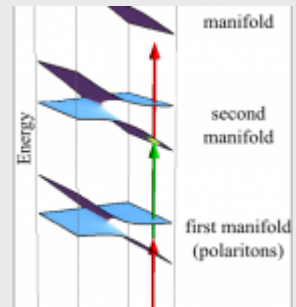


Coherent generation of nonclassical light on chip via detuned photon blockade - published in Physical Review Letters

The conversion of laser light into quantum light is one of the requisite of tomorrow's quantum technology. A popular trick to do so is the so-called polariton blockade, where the incoming classical light is broken down into a stream of isolated photons ("antibunched" light) thanks to the non-harmonic spacing of the energy levels of a strongly-coupled light-matter interface.



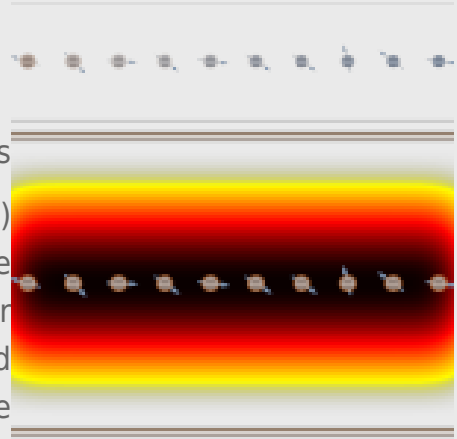
In 2012, [Fabrice Laussy](#) and [Elena del Valle](#) have identified with co-authors several factors to optimize quantum effects in strongly dissipative systems [1]. This is relevant in particular for semiconductors, which remain the platforms of choice for massive deployment. One of these factors is detuning, namely, rather than bringing light and matter in resonance as is usually sought to optimize strong-coupling, it is better instead to have them interact at a distance (in energy), allowing the classical laser to find room in between to excite various quantum resonances. The wider picture of polariton blockade in a detuned and dissipative environment is shown on the Figure.

Kai Müller, Armand Rundquist, Kevin Fischer and collaborators, from the group of Jelena Vučković in Stanford, have applied this requisite to generate record values of antibunching in the solid state, thanks to the detuned photon blockade configuration [2]. The Authors then proceed to further characterize the quantum state, in particular its higher purity. This result is not only a great on-chip achievement for technological applications, it is also a first and big step towards the control of deeper quantum effects in the solid state thanks to detuning, at the culmination of which lies the [N-photon emitter](#) [3], theorized by researchers of the Universidad Autónoma de Madrid.

[Excitons do the Long Jump - published in Physical Review Letters](#)

W

hen light is absorbed in organic materials, its energy is converted into excitons (electronic excitations) that normally move around by “hopping” from molecule to molecule. This is important in photosynthesis or solar cells, for example. There, the energy of the absorbed sunlight has to be brought to a “reaction center”, where it can be used to power chemical or electrical processes.



In many organic materials, energy transport is inefficient because of the large amount of disorder and motion of the molecules. The theoretical work, carried out by IFIMAC researchers Johannes Feist and Francisco J. Garcia-Vidal, shows that an extraordinary increase of the transportation efficiency (or “exciton conductance”) can be achieved by placing two mirrors on both sides of the organic material. The excitons can then not only hop from molecule to molecule, but also transfer their energy back into light trapped between the mirrors. When this happens quickly enough, the exciton and light behave as an effective new particle with hybrid properties borrowed from both constituents. In this regime of “strong coupling”, energy transferred into the system at one spot can efficiently “jump” over a large distance, bypassing the disordered collection of molecules.

Reference:

Extraordinary Exciton Conductance Induced by Strong Coupling, Johannes Feist and Francisco J. Garcia-Vidal, Phys. Rev. Lett. 114, 196402, (2015). [\[URL\]](#)

Condensed Matter Physics Center has been awarded with a "María de Maeztu" Grant

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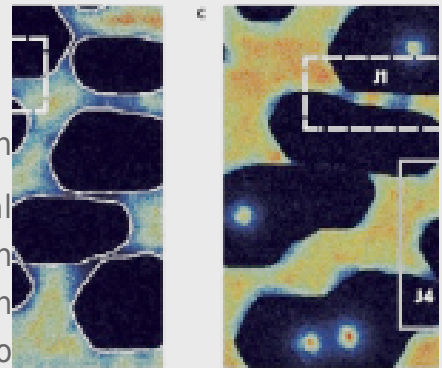
he Condensed Matter Physics Center (IFIMAC) has been awarded with a “María de Maeztu” grant corresponding to the Excelent Research Centers 2014 program financed by the Spanish I+D+i secretary. This grant will provide to our institute a total funding of 2.000.000 Euro for the next 4 years (2015-2019).

[Read more](#)



Direct Observation of Josephson Vortex Cores - published in Nature Physics

When a normal metal is brought in contact with a superconductor, Cooper pairs may leak into the metal inducing genuine superconducting properties in it, an effect generically referred to as proximity effect. In particular, if a metal is sandwiched between two superconductors, it can sustain the flow of a dissipationless or Josephson current. When a magnetic field is applied to a Josephson junction, the Josephson currents oscillate along the interface splitting up the junction into regions that enclose no net current, which are known as Josephson vortices. Contrary to Abrikosov vortices in type II superconductors, the Josephson vortices are supposed to lack of a normal core (where the superconductivity is completely suppressed). However, it was predicted by J. C. Cuevas and F. S. Bergeret in 2007 that if the weak link is made of a diffusive metal, the junctions can sustain Josephson vortices with true vortex cores inside the metal. Now, in collaboration with the Group of Spectroscopy of Novel Quantum States (Institut des Nanosciences de Paris and Université Pierre et Marie Curie), we report the first direct observation of these proximity Josephson vortices. In our case, the junctions are made of superconducting Pb nanoislands weakly linked by a normal (atomically thin) wetting layer of Pb, which is not superconducting. The Josephson vortices were imaged by means of a low-temperature scanning tunneling microscope, and they were revealed by the spatial modulation of the local density of state in the wetting layer induced by the magnetic field. Our results strongly suggest that it should be possible to induce these proximity vortices in novel quantum devices by purely electrical means. Moreover, we may anticipate the observation of these vortices in other superconducting weak links made of low-dimensional materials such as graphene.



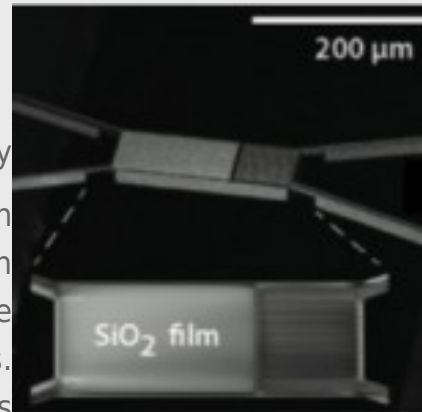
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Reference:

[Direct observation of Josephson vortex cores.](#) D. Roditchev, C. Brun, L. Serrier-Garcia, J. C. Cuevas, V. H. L. Bessa, M. V. Milosevic, F. Debontridder, V. Stolyarov, T. Cren. Nature Physics, in press (2015).

Enhancement of Near-field Radiative Heat Transfer Using Polar dielectric Thin Films - published in Nature Nanotechnology

Thermal radiation plays a major role in energy conversion, thermal management, and data storage. In recent years, several experiments on thermal radiation between bulk materials have demonstrated that radiative heat transfer can be greatly enhanced in nanoscale gaps. However, it was not clear whether such enhancements could be obtained with nanoscale films thinner than the penetration depth of radiation. In this work, our colleagues of the University of Michigan (the groups of Pramod Reddy and Edgar Meyhofer) have conducted near-field radiation experiments using a novel ultrasensitive calorimeter that demonstrate enhancements of several orders of magnitude in radiative heat transfer, even for ultra thin dielectric films (50 nm), at spatial separations comparable to or smaller than the film thickness. Researchers from IFIMAC (V. Fernández-Hurtado, J. Feist, F. J. García-Vidal and J. C. Cuevas) have explained these striking results making use of the theory of fluctuational electrodynamics. In particular, we have showed that the near field radiative heat transfer in polar dielectric thin films is determined by the excitation of cavity surface phonon polaritons. These surface electromagnetic modes have characteristic penetration depths that are of the order of the gap separating the receiver from the emitter. In practice, this implies that the entire near field thermal radiation emitted by a polar material comes from its surface. Thus, the thermal emission of a polar thin film is independent of its thickness, as long as the gap between materials remains smaller than the film thickness. Our findings have important implications to a variety of future energy conversion and heat transfer nanotechnologies.

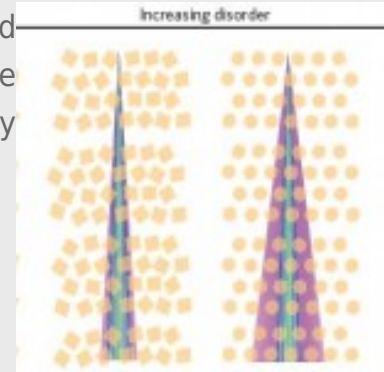


Reference:

[Enhancement of near-field radiative heat transfer in polar dielectric thin films](#). B. Song, Y. Ganjeh, S. Sadat, D. Thompson, A. Fiorino, V. Fernández-Hurtado, J. Feist, F.J. Garcia-Vidal, J.C. Cuevas, Pramod Reddy, Edgar Meyhofer. Publicado en Nature Nanotechnology (2015). doi:10.1038/nnano.2015.6

[Disorder Sets Light Straight - published in Nature Physics News and Views](#)

In a recent [Nature Physics News & Views](#) article entitled 'Disorder sets Light straight' [Jorge Bravo-Abad](#) discusses the fascinating discovery of light supercollimation assisted by transverse Anderson localization.

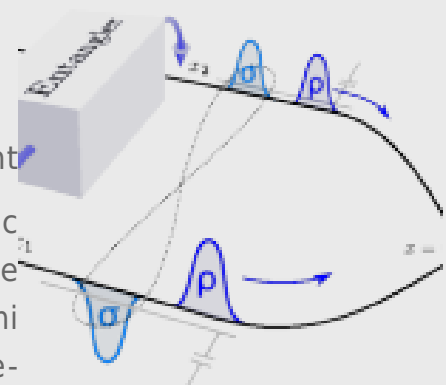


Abstract:

Non-diffractive light propagation based on perfectly periodic photonic structures has one fundamental drawback: it only works within a narrow frequency bandwidth, which makes supercollimation effects very sensitive to frequency variations of the propagating beam. Hsieh et al. now demonstrate that disorder can become an unexpected ally for tackling this problem. At first sight the approach of Hsieh et al. could seem counterintuitive. It is well known that structural disorder is detrimental to any optical functionality of a periodic photonic structure. But instead of battling disorder, they discovered a fundamental way to leverage it. As they report in *Nature Physics*, Pin-Chun Hsieh and colleagues demonstrate how disorder can enhance the collimation of light through Anderson localization – a universal wave phenomenon introduced almost six decades ago in the context of electronic transport in disordered solids.

[Detection of Spin Entanglement via Spin-Charge Separation in Crossed Tomonaga-Luttinger Liquids - published in Physical Review Letters](#)

In this work we demonstrate that simple dc current measurements can reveal the presence of electronic entanglement between two interacting nanowires. The effect is based on spin-charge separation, a non-Fermi liquid property characteristic of interacting one-dimensional systems.



Abstract:

We investigate tunneling between two spinful Tomonaga-Luttinger liquids (TLLs)

realized, e.g., as two crossed nanowires or quantum Hall edge states. When injecting into each TLL one electron of opposite spin, the dc current measured after the crossing differs for singlet, triplet, or product states. This is a striking new non-Fermi liquid feature because the (mean) current in a noninteracting beam splitter is insensitive to spin entanglement. It can be understood in terms of collective excitations subject to spin-charge separation. This behavior may offer an easier alternative to traditional entanglement detection schemes based on current noise, which we show to be suppressed by the interactions.

Reference:

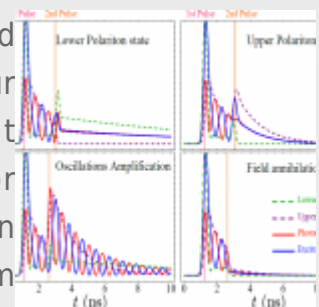
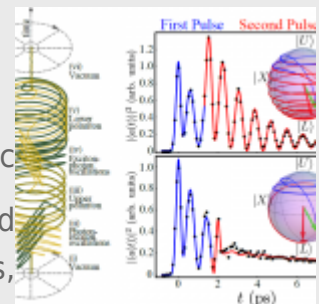
[Detection of Spin Entanglement via Spin-Charge Separation in Crossed Tomonaga-Luttinger Liquids](#), Phys. Rev. Lett. 113, 266401 – Published 23 December 2014.

[Ultrafast Control and Rabi Oscillations of Polaritons - published in Physical Review Letters](#)

The full control of Rabi oscillations in polaritonic semiconductor microcavities has been demonstrated and theorized by researchers of the department (D. Colas, J. P. Restrepo Cuartas, J. C. López Carreño, [E. del Valle](#) and [F. P. Laussy](#)) in collaboration with the group of Daniele Sanvitto (Lecce, Italie). These results were published in [Physical Review Letters](#).

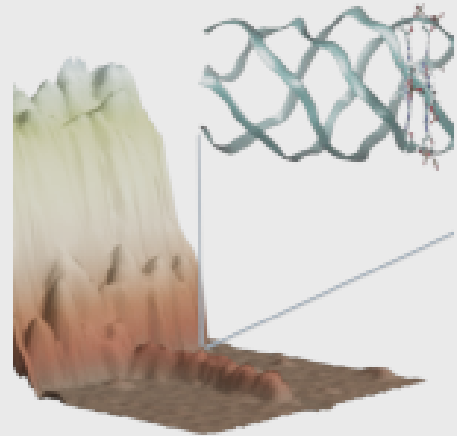
Abstract:

We report the experimental observation and control of space and time-resolved light-matter Rabi oscillations in a microcavity. Our setup precision and the system coherence are so high that coherent control can be implemented with amplification or switching off of the oscillations and even erasing of the polariton density by optical pulses. The data are reproduced by a quantum optical model with excellent accuracy, providing new insights on the key components that rule the polariton dynamics.



[Long-range Charge Transport in Single G-quadruplex DNA Molecules - published in](#)

A single G4-DNA molecule has been shown to be able to transport charge over very long distances by Livshits et al. whose findings have been published in [Nature Nanotechnology](#).



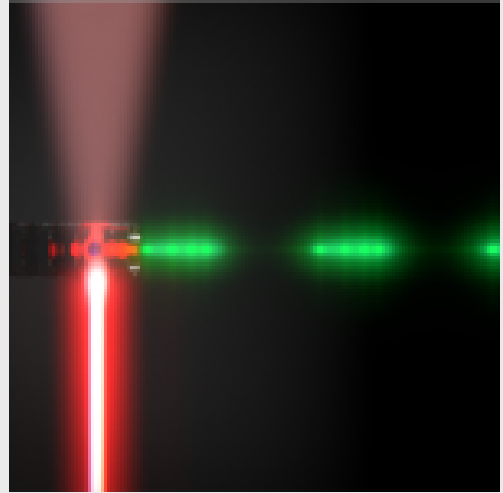
Abstract:

DNA and DNA-based polymers are of interest in molecular electronics because of their versatile and programmable structures. However, transport measurements have produced a range of seemingly contradictory results due to differences in the measured molecules and experimental set-ups, and transporting significant current through individual DNA-based molecules remains a considerable challenge. Here, we report reproducible charge transport in guanine-quadruplex (G4) DNA molecules adsorbed on a mica substrate. Currents ranging from tens of picoamperes to more than 100 pA were measured in the G4-DNA over distances ranging from tens of nanometres to more than 100 nm. Our experimental results, combined with theoretical modelling, suggest that transport occurs via a thermally activated long-range hopping between multi-tetrad segments. These results could re-ignite interest in DNA-based wires and devices, and in the use of such systems in the development of programmable circuits.

Reference:

Long-range charge transport in single G-quadruplex DNA molecules, G. I. Livshits, A. Stern, D. Rotem, N. Borovok, G. Eidelstein, A. Migliore, E. Penzo, S. J. Wind, R. Di Felice, S. S. Skourtis, [J. C. Cuevas](#), L. Gurevich, A. B. Kotlyar, D. Porath. *Nature Nanotechnology*, advanced online publication (October 26th, 2014). DOI: [10.1038/nnano.2014.246](https://doi.org/10.1038/nnano.2014.246).

A new type of light has been theorized by C. Sánchez Muñoz et al. whose findings have been published in [Nature Photonics](#).



Abstract:

Controlling the output of a light emitter is one of the basic tasks in photonics, with landmarks such as the development of the laser and single-photon sources. The ever growing range of quantum applications is making it increasingly important to diversify the available quantum sources. Here, we propose a cavity quantum electrodynamics scheme to realize emitters that release their energy in groups (or ‘bundles’) of N photons (where N is an integer). Close to 100% of two-photon emission and 90% of three-photon emission is shown to be within reach of state-of-the-art samples. The emission can be tuned with the system parameters so that the device behaves as a laser or as an N -photon gun. Here, we develop the theoretical formalism to characterize such emitters, with the bundle statistics arising as an extension of the fundamental correlation functions of quantum optics. These emitters will be useful for quantum information processing and for medical applications.
