

SQUIRREL: SENSING QUANTUM INFORMATION CORRELATIONS

FINAL PUBLISHABLE SUMMARY REPORT

1 Full List of Publications

The main scientific results of SQUIRREL have been detailed and discussed in the Mid-Term report. The scientific output this gave rise to is listed here (“IF” is “Impact Factor”):

1. *Emitters of N-photon bundles*, C. Sánchez-Muñoz, **E. del Valle**, A. González-Tudela, S. Lichtmanecker, K. Müller, M. Kaniber, C. Tejedor, J.J. Finley and F.P. Laussy. *Nature Photonics* 8, 550 (2014). Also see the News and Views titled *Cavity quantum electrodynamics: A bundle of photons*, please by Dmitry V. Strekalov. In this text, the Author Contributions opens with: “F.P.L. and E.d.V. proposed the idea.” IF: 29.958
2. *Spontaneous, collective coherence in driven, dissipative cavity arrays*, J. Ruiz-Rivas, **E. del Valle**, C. Gies, P. Gartner and M. J. Hartmann, *Phys. Rev. A* 90, 033808 (2014). IF: 2.991
3. *Ultrafast control of Rabi oscillations in a polariton condensate*, L. Dominici, D. Colas, S. Donati, J. P. Restrepo Cuartas, M. De Giorgi, D. Ballarini, G. Guirales, J. C. López Carreño, A. Bramati, G. Gigli, **E. del Valle**, F. P. Laussy, D. Sanvitto. *Phys. Rev. Lett.* 113, 226401 (2014). Covered by mi+d and Aula Magna. IF: 7.728.
4. *Violation of classical inequalities by frequency filtering*, C. Sánchez Muñoz, **E. del Valle**, C. Tejedor, F. P. Laussy. *Phys. Rev. A* 90, 052111 (2014). IF: 2.991.
5. *Measuring photon correlations simultaneously in time and frequency*, B. Silva, A. González Tudela, C. Sánchez Muñoz, D. Ballarini, G. Gigli, K. W. West, L. Pfeiffer, **E. del Valle**, D. Sanvitto, F. P. Laussy. arXiv:1406.0964.
6. *On-chip generation of indistinguishable photons using cavity quantum–electrodynamics*, K. Müller, A. Rundquist, K. A. Fischer, T. Sarmiento, K. G. Lagoudakis, Y. A. Kelaita, C. Sánchez Muñoz, **E. del Valle**, F. P. Laussy, J. Vücković. arXiv:1408.5942. Accepted for publication in *Phys. Rev. Lett.* IF: 7.728.
7. *Spanning the full Poincaré sphere with polariton Rabi oscillations*, D. Colas, L. Dominici, S. Donati, A.A. Pervishko, T.C.H. Liew, I.A. Shelykh, D. Ballarini, M. de Giorgi, A. Bramati, G. Gigli, **E. del Valle**, F.P. Laussy, A.V. Kavokin, D. Sanvitto. arXiv:1412.4758. Accepted for publication in *Light: Science & Applications*. In this text, the Author Contributions mentions: “EdV supervised the theory”. IF: 8.476.
8. *Optimization of photon correlations by frequency filtering*, A. Gonzalez-Tudela, **E. del Valle**, F. P. Laussy. *Phys. Rev. A* 91, 043807 (2015). IF: 2.991.

Four manuscripts, under preparation at the time of writing, but acknowledging the SQUIRREL project will be sent to publication shortly. Their fate can be followed on the project’s website: <http://laussy.org/wiki/squirrel>.

2 Future directions

The SQUIRREL project terminated leaving in its trail a direct continuation of its workframe, namely, instead of using sensors to probe the output of a quantum system (tagging its photons in frequency in the process), one addresses the non-perturbative excitation of a quantum source onto a receiving end (typically a polariton). This concept is to be presented as an invited talk in the “Hybrid Photonics and Materials International Conference” in Santorini, Greece, end of May 2015, and in the manuscript “*Exciting polaritons with quantum light*”, to be submitted to *Phys. Rev. Lett.*

3 Public Outreach

The SQUIRREL project has been praised by its Reviewers in Brussels for its public outreach. While most of the planned activities have been prepared, contacts established and a schedule fixed, some of them will take place after completion of the project. They will be documented on the project’s website: <http://laussy.org/wiki/squirrel>. One action of particular impact to disseminate the results of the SQUIRREL project is the graduate level course at the summer school of Nanophotonics and Photovoltaics at the ISNP-2015 in Cefalu, Sicily, in mid-September 2015, to be delivered by the fellow on results and concepts produced by the project. Other actions to the more general public include:

3.1 “Café con Investigadores”

A meeting has been proposed to the Second Year students of the Universidad Autónoma de Madrid to give them the opportunity to interact after the class with working scientists. The fellow presented the various schemes of funding provided by national schemes and the European Union, with an emphasis on the Marie Curie fellowship.

3.2 “Trabajo: Investigadora”

[Pending] A one-hour meeting with high-school students of the IES José Luis Sampedro school in Madrid, in collaboration with the physics teacher Marisa Vila, is scheduled for late 2015, to inform the young public of the prospects of scientific research at the University. The nature and excitement of the work conducted there, and some wonders of quantum mechanics, will be presented

in a short presentation (20 min), followed by discussions & questions (30 min).

3.3 European Researchers night

[Pending: to be held on 25th September 2015] A stand will be held by the fellow at the European Researchers night, in collaboration with the “Oficina de Relaciones Internacionales” of the Universidad Autónoma de Madrid. The presentation of the Fellow’s activity to the general public will consist in an interactive game where the participants will first answer a series of questions displayed on an A0 poster, about experiments in Quantum Mechanics designed to stir common sense and challenge one’s everyday experience. The answers will then be contrasted to the real outcome according to the principles of Quantum Physics. We will discuss in simple terms the concepts supporting our modern understanding of the world.

4 Output (O) and Impact (I)

The SQUIRREL project was to run for one year only. The reason is that the project was not successful on its first submission and has been funded upon resubmission the following year, for which only one year was available since during this time, the Researcher was appointed a five year tenure track position at the Universidad Autónoma de Madrid, to be started no later than mid-December 2014. Despite difficulties from the host organization in accommodating the Marie Curie grant in these conditions, and thanks to the intermission of the EU officer (Christina Marcone), it still could be funded for a period of nine months and two weeks. Despite this very short time for a research activity, the output of the project and the impact it generated has been exceptional and beyond its own expectations:

- O1: The project has given rise to 12 texts, either already published in high-impact factors journals, under review or still under preparation but to be shortly released with acknowledgements to the project. The project has given rise to four presentations in international conferences (two invited) by the Researcher herself (significantly more if including all co-authors).
- I1: The 2PS, the central concept articulating the theoretical proposal, is now a physical reality.
- O2: The concept for a new device, the “*bundler*”, generating a new type of light. This has been published in the prestigious Nature Photonic journal, which is exceptional for a purely theoretical work.
- I2: A News & Views in Nature Photonics describing the Bundler, by D. Strelakov, opens with “*Our concept of light has undergone a remarkable evolution*” and concludes with “*And in terms of fundamental science, the concept of light has received yet another interesting perspective*”.
- O3,I3: High-profile experimental groups actively pursue further experimental implementations of the theoretical effects predicted by SQUIRREL, including violation of Bell’s inequalities (group of Prof. A. Müller in Florida) and implementation of the bundler (group of Profs. D. Sanvitto in Lecce, J. J. Finley in Munich and J. Vůcković in Stanford). The Project concludes by opening a new line of research of exciting devices with the output of the correlated coloured-photons studied by the project.

Last but not least, in another certainly quite unusual outcome of such a project, the Researcher also had the time (and good fortune) to become pregnant and gave birth to her first child, in January 2015, bearing the names of both the Researcher and the Scientist in charge: Julia Laussy del Valle.

In conclusions: the project has been a real success story.