Physics Colloquium

- September 12, 2019 at 4:25PM
- 316 Lewis Lab.
- Refreshments at 4:00PM

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Speaker: Ivan Biaggio

Professor of Physics, Lehigh University

"The life and times of excitons in an organic "semiconductor": fission, fusion, entanglement, transport, and dissociation"

In larger organic molecules, the first electronic excited state can have a significantly lower energy in a triplet configuration than in the photoexcited singlet configuration. In molecular crystals where the triplet exciton energy is less than half the singlet exciton energy, photon absorption results in a singlet exciton that can quickly undergo a "fission" process into two triplet excitons. The pair of triplet excitons generated in this way is entangled, with total spin of zero. The excitons that are part of this pair then diffuse in a complicated way in the crystal matrix (while their spin remains entangled) which is an interesting process by itself. But the energy that the triplet excitons transport could also conceivably be used in future photovoltaics systems. In the rubrene material, the triplet state energy is just about half the singlet state energy, which means that if by chance the diffusing excitons meet again, they have a finite probability of undergoing a "fusion" process back into a singlet exciton, which can then result in photon emission. Despite the fact that the probability of meeting again is low for 3D diffusion, and that the probability that this results in photon emission is also low, we can harvest these photons and use them to study the behavior of the entangled triplet exciton pair and how its two members wander around in the crystal. We believe that we can say intelligent things about the dimensionality of the diffusion process (1D? 2D? 3D?) just by looking at the time-dynamics of the stream of photons generated when the triplet excitons meet again. We also have seen that the two triplets in the entangled pair maintain spin-correlation for at least 30 ns while they independently diffuse around in the crystal. This was done by observing quantum beats in the fluorescence emitted by fusion events. The talk will discuss the various processes involved in the exciton dynamics in rubrene, highlighting several strange things and open questions.

Dr. Biaggio *got his PhD from the Swiss Federal Institute of Technology (ETH) in Zürich, with a dissertation about some strange effects connected to photoexcitation and space-charge fields in a ferroelectric perovskite. He then went to the University of Southern California to work with Prof. Hellwarth on large polarons, nonlinear optical effects in atomic vapors, and on building an "atomic correlator". After a second postdoctoral stay at Orsay, near Paris, he went back to ETH, where he led a team that worked on vapor deposition or organic light emitting diodes and transistors and also did research on nonlinear optics, charge-carrier photoexcitation, mobility anisotropy, and four-wave mixing. While there, he received the "venia legend", became what is called a "Privatdozent", and then left to come to Lehigh in 2002. At Lehigh, he has established a research program dedicated to light-matter interactions, condensed matter physics, nonlinear optics, and materials for photonics. Recently, his research group has worked on uncovering some exciting properties of singlet and triplet excitons in a particularly nice organic crystals.*