Proximitized Materials: From Spintronics to Majorana State

Speaker: **Igor Zutic**

University at Buffalo (USA)

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Abstract: Scaled-down heterostructures and atomically-thin materials suggest a novel approach to systematically design materials as well as to realize exotic states of matter. A given material can be transformed through proximity effects [1] whereby it acquires properties of its neighbors, for example, becoming superconducting, magnetic, topologically nontrivial, or with an enhanced spin-orbit coupling. Such proximity effects not only complement the conventional methods of designing materials, but can also overcome their various limitations. In proximitized materials it is possible to realize properties that are not present in any constituent region of the considered heterostructure. After providing some background on proximity effects we discuss device implications of magnetism leaking into initially a non-magnetic region which could be useful for spintronics [1-3]. We show that gate-tunable band topology allows helicity reversal of the emitted light [4] and novel paths to spin lasers [5]. Inspired by the 1937 prediction of Majorana fermions which are their own antiparticles, there is an intensive effort to realize their condensed-matter analogs. Combined magnetic and superconducting proximity effects may enable topologically-protected Majorana bounds states (MBS) for fault-tolerant quantum computing. We discuss our proposal for realizing such MBS in 2D platforms and the challenges for their experimental demonstration [6]. Recent measurements of proximity-induced topological superconductivity [7] provide novel opportunities for controlling MBS and probing their non-Abelian statistics [8].

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**Igor Žutić** is a Professor of Physics at the University at Buffalo, the State University of New York. He received PhD in theoretical physics at the University of Minnesota in 1998. His work spans topics from spin transport, superconductors, and Majorana fermions, to magnetic nanostructures, proximity effects, and 2D materials. His predictions for spin devices such as spin-photodiodes, transistors, and lasers, have been experimentally realized. With Evgeny Tsymbal, he coedited 3-volume Spintronics Handbook (CRC Press, 2019). Igor Žutić is a Fellow of the American Physical Society.
