LENS/CMP Seminar

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Title: “Search for Majorana fermions in semiconductor nanostructures”

Abstract: Majorana fermions (MFs), particles that are their own antiparticles and obey exotic non-Abelian exchange statistics, have gained considerable attention in recent years due to several proposals for the existence of Majorana modes in semiconductor systems as quasiparticle excitations. There were some experimental attempts to observe the MFs in semiconductor systems as well as in a ferromagnetic atomic chain by placing the system in close proximity to a conventional superconductor. One most promising candidate for realization of Majorana fermions is the observation of the topological superconducting phase in a one-dimensional semiconductor wire proximity coupled to an s-wave superconductor and with large Rashba spin-orbit coupling. By tuning the chemical potential of this system in the gap region created by an applied magnetic field, the system effectively becomes spinless and supports MFs at the edges of the wire. There are strong indications for the presence of these long sought-after particles in recent experiments, but an unambiguous discovery still remains elusive.

In this talk, I shall give a brief introduction on our work on Majorana fermions in semiconductor nanostructures, in particular, in an elliptical quantum ring. For rings with sizes of few hundred angstroms and for certain range of values of the chemical potential and an applied magnetic field, the system is in a topological superconducting phase where there are strong indications of the presence of Majorana fermions. The Majorana fermions are well separated from each other in the angular coordinates. The charge-density jumps due to the presence of the Majoranas are found to be uniformly distributed along the ring and can perhaps be detected by scanning charge measurements. Semiconductor quantum rings with a few interacting electrons are available in the laboratories. Therefore long sought-after Majorana fermions could perhaps be observed in such a system.