PHYS1415: Quantum Physics at the Nanoscale (Fall 2018)

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Pre-requisites: PHYS 174 (or 475), PHYS 175 (or 476), PHYS 219 (or 520)

Credits: can be taken instead of PHYS 1426 (modern physics lab), and to satisfy the W requirement (sign up for 1661 to receive credit)

Schedule: flexible! (based on student's availability) – get a permission if your schedule shows conflict.

This is an advanced laboratory course focused on the experiments first performed in the XXI century in the field of quantum computing and nanoscience. This field is experiencing a rapid boom with heavy government and industrial support from Intel, Microsoft, IBM, Google. This is an inquiry-based laboratory course without a laboratory manual to follow. The class will closely mimic a real physics research project and may include elements of original research with a possibility to contribute to peer-reviewed publications. Students will work as one team to pursue a single project during the entire semester. The project will be formulated together with students out of a choice of several options that involve quantum transport measurements of devices based on nanowires, nanoribbons or single-atom thick flakes.

The project will follow three main stages. Stage 1 will be based at the Nanofabrication and Characterization Facility (NFCF, http://nano.pitt.edu/) at the sub-basement level of Benedum Hall. At this facility often referred to as 'the cleanroom', students will learn methods of nanofabrication, receive training on equipment such as an electron beam microscope, electron beam evaporator, optical lithography tools; Students will fabricate their own nanoscale samples for their project. Stage 2 will involve measurements of samples created during stage 2 at the instructor's laboratory in the Old Engineering Hall (room B05, http://frolovlab.org/) equipped with the low-temperature (10 mK) electrical transport measurement setup. Stage 3 will be dedicated to the analysis of the gathered data, possibly including numerical simulations using a python-based KWANT code, and the writing of a final report (W option).

The development of the course is in part supported by the National Science Foundation Partnership in International Research and Education on Hybrid Materials for Quantum Science and Engineering (PIRE:HYBRID). Within this project, undergraduate students get an opportunity to do a 10-week research internship in France on topics covered in this course. This summer, three of the students that took PHYS1415 are doing their internships in Grenoble and Toulouse. More information will be available at the end of the Summer at http://pirehybrid.org/