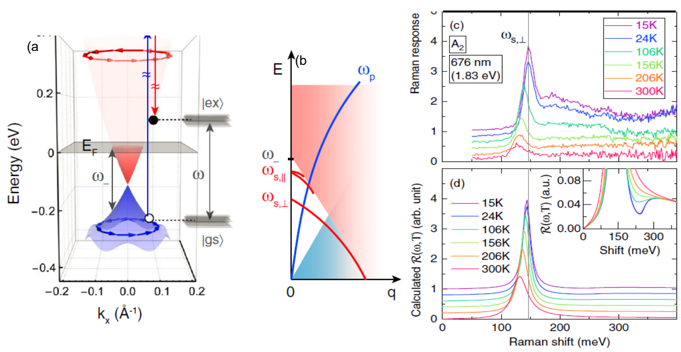
M.Sc. student position will be available, starting in the Fall 2021 / Winter 2022, in the group of Professor Saurabh Maiti

Department of Physics, Concordia University, Montreal, Canada.



Demonstration of application of our theory for collective mdoes applied to topological insulator Bi_2Se_3. (a) Electronic states on the surface of the material. (b) The dispersion of the exotic chiral-spin modes. (c) Experimental data for the intensity of the Raman signal. (d) Theoretical calculation of the Raman intensity. Figures from PRL 119,136802 (2017).

Collective phenomena in low dimensional systems: Broadly my group is interested in understanding the role of various quantum degrees of freedom (arising from orbital, band, valley etc) in the collective response of the system. Studying the collective response helps understand how the quantum materials respond to the experimental probes we use to study their properties. This means that everything we theoretically predict can be directly checked by experiments. This is always exciting.

The systems we are interested in are unconventional superconductors and spin-orbit coupled 2D materials. My group's research theme is based on investigating effects of electronic correlations in various quantum phases of such materials. Our predictions have already been verified in 3 different experiments (see figure) and we look to carry this momentum forward with your help for newer quantum materials. Several projects are open for extremely motivated students at various levels of complexity. One of them is stated below:

Raman signature of a nematic superconductor:

Superconductivity is perhaps one of the most intriguing and heavily debated quantum phenomena in modern condensed matter physics. One, amongst the many, feature that makes it so is its ability to co-exist with many other quantum phases: like density-waves, magnets, and even rotational symmetry broken states: which is called the nematic state. Although the term originated in liquid crystals, more and more solid-state systems demonstrate such a state where the rotational symmetry is spontaneously broken (but not the translation one). Ruthenates, unconventional superconductors (Fe-based) are some of the well studied examples.

Over the years, Raman spectroscopy has positioned itself as an important tool to study symmetry breaking in quantum phases. It can not only detect the superconducting transition but also the nematic one. Further, in the more recent Fe-based superconductors, it has been demonstrated that superconductivity and nematicity can actually coexist and that there is a subtle interplay of these quantum phases. Each of these phases has its characteristic collective response. In this project, we wish to address the interplay of the two phases from the viewpoint of the collective modes in the respective

7141 Sherbrooke Street West, Montreal, Quebec, Canada H4B 1R6 Tel.: 514 848-2424 ext. 3270 Fax: 514 848-2828 http://physics.concordia.ca

states and study how the modes interact as the phases begin to coexist. Not only will this help us understand the coexistent-state better, but suggest new experiments that can identify the novel collective signatures arising from the interplay of the two orders. Our group has developed techniques to study the collective response of unconventional superconductors, in general, and also understand their Raman spectroscopy signature. We wish to extend such techniques to include the nematic state. The main challenge involves including new interaction matrix elements in the coexistent problem. While the machinery already exists, we need motivated individuals who will tailor it to this specific problem.

Concordia Department of Physics is a growing department in a university with rapidly increasing rating. We offer research-based M.Sc. and Ph.D. programs. Our faculty members conduct research in the areas of Condensed Matter Physics (theoretical and experimental), Molecular Biophysics, Medical Physics / Imaging, Photonics, Theoretical High Energy Physics, Computational Physics and Physics Education.
Successful applicants will be offered financial packages consisting of RA, TA and various awards of at least 20,000 CAD per year (often more), for 4 years (Ph.D.) or 2 years (M.Sc.). International students will be offered tuition remissions or other awards to compensate for the international tuition fees.
Please contact Professor Saurabh Maiti (saurabh.maiti@concordia.ca) or Professor Valter Zazubovits, Graduate Program Director (valter.zazubovits@concordia.ca) for more information.