Research Projects

The common theme underlying my research may be broadly defined as *Interactions of Particles with Matter*. More specifically, I study a variety of processes occurring when accelerated beams of electrons or atomic, molecular and cluster ions interact with the bulk or surface regions of solid and plasma targets, as well as with nano-meter sized matter. Such processes have found many technological applications in areas such as catalysis, materials science, fusion technology, fabrication of micro-electronic devices, radiation medicine, and environmental studies. Moreover, many interesting new applications are emerging from contemporary experimental research. Here are some intriguing examples, listed in chronological order as regards my involvement with various research projects.

1. Understanding the dynamics of *Coulomb explosion* of fast *cluster ions* is important for achieving the material modifications at the nanometer scale or in the quest for efficient energy deposition in fusion reactors.
2. Fluctuations of the electric field above *randomly rough surfaces* that exhibit structural and chemical irregularities may impart strong influence on electronic properties of nanometer-scale electronic devices or on the transmission of electromagnetic waves.
3. The so-called *dusty plasma*, occurring in the conventional plasma processing of micro-electronic devices, exhibits crystallization of the micron-sized dust grains, which may be controlled by ion flow.
4. *Carbon nanotubes* are nanometer-wide hollow cylinders with the walls made of one-atom thick layer of carbon atoms that may be used as "wave-guides" for various particles, from the accelerated electron and ion beams to the DNA molecules.
5. My involvement with carbon nanostructures has recently drifted towards *graphene*, where I got interested in its applications to Plasmonics and Biochemical Sensors. This latter direction brings me closer to an interface with Electrochemistry.
6. Finally, I got recently interested in modeling the experiments on *photoluminescence of colloidal nanoparticles* made of a transparent conducting oxide, with the goal of describing the effects of spatial correlation between their defects.

My research focuses on mathematical modelling and theoretical description of such processes, with the goal of understanding the observed phenomena and delineating possibilities for new applications. I am proud to say that I occasionally collaborate with various experimental groups and that some of my theoretical models have found good use in the interpretation of their data.

In my work, I often use *stochastic methods*, which I occasionally teach in a graduate course. In near future, I plan to extend the focus of my research to applications of Stochastic Processes in the new directions that will interface my projects with Biology.

As far as the *graduate student training* is concerned, my research requires skills from several areas of *Mathematics*: vector calculus, complex analysis, ordinary and partial differential equations, integral equations, calculus of variations, probability and statistics, numerical analysis, and symbolic computation. In addition, familiarity with theoretical models from several areas of *Physics*, such as quantum mechanics, solid state physics, plasma physics, and statistical mechanics, is definitely a bonus for prospective graduate students, but is not necessary.