Research Interests. My research interests cover a broad array of topics ranging from biological physics to non-equilibrium statistical mechanics, the foundations of quantum mechanics and quantum field theory.

In Biological Physics our group is performing both experimental and theoretical work to uncover fundamental physical principles that underlie the formation of functional neuronal networks among neurons in the brain. One of the primary challenges in science today is to figure out how as many as 100 billion neurons are produced, grow, and organize themselves into the truly wonderful information-processing machine which is the brain. We combine high-resolution imaging techniques such as atomic force microscopy and fluorescence microscopy to measure mechanical properties of neurons and to correlate these properties with internal components of the cell. Our group is also using mathematical modeling to predict axonal dynamics and network formation. The aim of this work is twofold. On the one hand we are using tools and concepts from experimental and theoretical physics to understand biological processes. On the other hand, active biological processes in neuronal cells exhibit a wealth of fascinating phenomena such as pattern formation, collective behavior, non equilibrium phase transitions and dynamics, and thus the insights learned from studying these biological systems broaden the intellectual range of physics.

To capture the complexity of neuronal interactions we use theoretical methods from statistical mechanics, many-body physics and field theory such as: stochastic differential equations, Fokker-Planck formalism, Markov processes, effective energy landscape etc. I am also interested in applying the theory of stochastic processes to quantum mechanics and constructive quantum field theories (see research link below).

My interests in condensed matter physics include quantum transport in nanoscale systems (carbon nanotubes, graphene, hybrid nanostructures), quantum many-body physics, topological insulators, biomaterials, and scanning probe microscopy. Follow the links below to learn more about our research.
Some Representative Publications:


