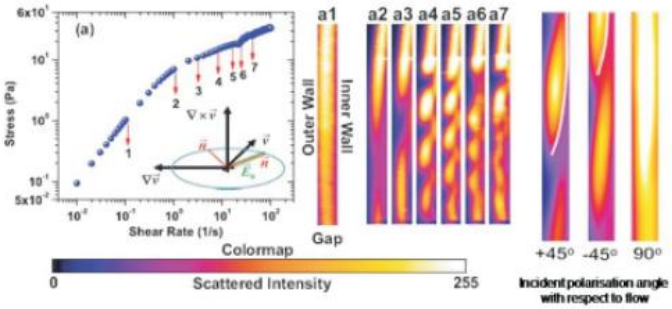
Dr. Rajesh Ganapathy

Faculty Fellow
Ph. D. (Physics)
from Indian Institute of Science

Soft Condensed Matter

Our research focuses on soft condensed matter physics. A few examples of soft materials include colloidal suspensions, polymers, liquid crystals and bacteria. Soft materials comprise of mesoscopic structures, size ranging from nanometers to microns, held together by energies comparable to the ambient thermal energy. Weak external stimuli, of the order of the thermal energy, couple strongly to soft matter microstructure that in turn determines the macroscopic response. The above characteristics of soft materials are exploited in numerous applications that include ketchups, automotive lubricants and flexible e-ink displays. Understanding the structure-response relationship of soft materials is essential for identifying properties exclusive to this class of condensed matter and will directly impact the development of novel soft materials with tailor-made properties.



The research problems we address include: self-assembly in colloids and surfactants, active particles and response of soft matter to external perturbations such as shear, electric and magnetic fields. We use confocal microscopy, light scattering, rheology and optical tweezers to probe our systems.

Colloidal Epitaxy

Epitaxial growth processes play a fundamental role in growing large defect free single-crystals, fabricating semiconductor devices and designing coatings with novel optical and mechanical properties. Although epitaxial growth has been studied extensively only in the case of atoms, it is also a promising route to self-assemble nano and micron scale particles into microstructures with numerous technological applications. We have shown that well-established 2D island nucleation and growth laws that dictate atomic epitaxy also govern the epitaxial growth of larger scale particles. We have also uncovered a new mechanism that leads to step-edge and corner barriers, which govern film morphology, in colloidal epitaxial growth. Our current research goals are to study the epitaxial self-assembly of particles with directional interactions, such as Janus particles, and to probe the effect of lattice mismatch on the nucleation and growth process.

Dynamics in Soft Materials Subjected to Shear

The response to an external perturbation, such as shear, in soft materials is always accompanied by a microstructural change. Understanding the correlation between such external perturbations and the microstructure has been a central focus of soft matter research. We had earlier observed chaotic stress-relaxation dynamics when orientable fluids, comprising of wormlike micelles, are subjected to a steady shear rate beyond a critical value. By performing in-situ polarized scattering measurements, we were able to show that the dynamics observed in the bulk response, in our case the stress, is a manifestation of the dynamics observed in the local nematic order. Our group is currently involved in setting up an instrument facility, a commercial rheometer mounted on a confocal microscope, which will allows us to get 3D realtime structural information of many soft matter systems when they are subjected to a shear force. This will enable us to better understand various phenomena such as shearthickening, aging in glassy systems, shear-induced phase transitions, etc. We will also be studying the effect of templated shear surfaces on the structure and bulk rheological behaviour.