SPECIALITIES
Statistical physics, molecular dynamics, complex non-linear systems and networks, rigidity percolation, nanostructure problems, device models.

RESEARCH FOCUS
Current interests include: (i) phase behavior of polymer-nanoparticle mixtures with applications to organic solar cells; (ii) phase behavior of nanoparticle-lipid bilayer systems with applications to nanotoxicology; (iii) finding the atomic structure of non-crystalline materials, such as isolated nanoparticles and complex molecules, involving the definition and solution of novel inverse problems; (iv) ultrafast nanocrystallography and applications to ultrafast processes in materials. An ongoing basic theory interest is phase transitions in complex, frustrated networks, particularly problems that lie at the interface between combinatorial optimization and statistical physics such as spin glass, K-SAT and MIS problems.

Molecular dynamics images of a nanoparticle interacting with a lipid bilayer. Left: A small hydrophilic nanoparticle does not penetrate the lipid, but it does deform the lipid. Right: Lipid completely covers a larger hydrophilic nanoparticle leading to rupture of the lipid membrane. An experimental group at MSU is measuring the current across a suspended lipid bilayer and finds current spikes when nanoparticles are introduced into the system. The dynamics of membrane rupture and healing is believed to cause the current spikes.