RESEARCH PROGRAM

Science and Engineering Abstracts
for Grants Awarded in December 2019

Montana State University
Bozeman, MT
Eric Boyd, Tullis Onstott, Tom Kieft, Barry Freifeld, David Mencin, Carol Finn, Susan Bilek, Jeff Hungerford, Christina Rush, Shazia Hakim
$1,000,000
December 2019

University of Arizona
Tucson, AZ
Mohammed Hassan
$1,100,000
December 2019

In the last decade, Ultrafast Electron Microscopy (UEM) has imaged atomic motion in real time and space, and table-top tools have opened up a vast range of science. Current UEM research focuses on improving both spatial and temporal resolution to resolve the electron dynamics of matter on sub-femtosecond timescales. Yet the imaging of electron dynamics remains beyond reach. The first project goal is to enhance the temporal resolution for electron microscopy to the extreme limits of an attosecond timescale, which is a thousand-times faster than cutting-edge UEM—an advance the PI calls "Attomicroscopy." The PI will attempt to achieve this extreme imaging speed by generating single isolated attosecond electron pulses. Specifically, this optical gating approach will use a laser pulse to control, tame, and confine the burst of free electrons inside the microscope on an attosecond timescale. Attomicroscopy will open a new era to both directly image and record electron motion in action, for the first time. As a second goal, the proof-of-principle for the unique Attomicroscopy camera is to directly record movies in real time and space for the surface-plasmon electron motion of a silver nanostructure. The images and movies will reveal the electronic motion in the context of nanostructure morphology, and potentially pave the way to laser-driven, million-times faster electronics that shape the future of information technology.

University of California, Santa Barbara
Santa Barbara, CA
Omar Saleh, Enoch Yeung
$1,000,000
December 2019

Chromatin packaging, on multiple scales, is now understood to be driven in part by liquid-liquid phase transitions, typically involving droplets of biomolecules that surround and sequester genomic segments. Further, the phase separations are themselves regulated by genetic outputs. Phase transitions differ strongly from classic biomolecular interactions, exhibiting discontinuous responses to solution changes and unique dynamics (e.g. nucleation). How these phenomena affect regulation is an open question. These investigators will illuminate this issue using a synthetic chromatin system consisting of self-assembled DNA particles that phase separate to form droplets. The DNA liquid will be interfaced with a gene such that liquid formation modulates transcription, while the transcribed RNA modulates liquid stability. The resulting feedback network will permit chromatin-like phase-based autoregulation in a well-controlled model system. The researchers will exploit this genetically-controlled phase behavior to create