**Current research:** type-1.5 superconductivity: a superconductivity falling outside the usual Type-I/Type-II dichotomy predicted in E. Babaev & J.M. Speight, Phys. Rev. B72 (2005) 180502.
Current research 2: Projected novel states of matter in hydrogen under ultrahigh compression

**Experimental aspects:**
New ultra-high pressure/small length scale technologies

**Theoretical aspects:** Novel type of quantum fluids, novel aggregate super state of matter, novel rotational and magnetic response and transport properties. A new window in the microworld.
OTHER QUESTIONS WE CURRENTLY STUDY:
Quantum ordered states of metallic hydrogen:
1. Microscopic and quantitative theory.
2. Observability challenges: Small samples at ultrahigh pressure. How the protonic or deuteronic superconductivity can be measured? We need further studies of possible experimental signatures and probes at ultra-high pressures (including quantitative theory).
3. Incorporation in the theory the effects of the intercomponent dissipationless drag (may be very strong at these densities).

New models for neutron star interior, prothonic-hyperonic condensates mixture? Current models of neutron star interior consisting of a mixture of hardonic superfluids could not be constrained with observed slow precession of some pulsars. We find that there are actually new effects which may allow for slow precession.

Neutron star physics in a terrestrial laboratory?
The key feature of the standard neutron star interior model is a strong negative dissipationless drag. But the recent progress in ultra-cold atoms can in principle also allow to create negative dissipationless drag in superfluid mixtures in optical lattices. Can cold atoms in optical lattices model this aspect of physics of neutron stars?

Artificial “toy metallic hydrogen”? Advanced layer-by-layer deposition technique allows to create superconductiong structures possessing unusual symmetries on large length scales, could one create the systems which would mimic aspects of metallic hydrogen physics?

Metallic hydrogen via protonic quantum sublattice melting in hydrogen-rich alloys at ultra-high pressures?

Other systems: supersolidity, Dipolar superfluidity, multiflavor dipolar superfluidity, spin-superfluidity in charged systems.

More information is available at
http://people.umass.edu/qmatter/
http://people.umass.edu/egorb/