Abstract:

Modern cosmology poses deep, unanswered questions about the nature of the universe. What is the dark energy that causes the accelerating expansion of the universe? What is the dark matter whose gravitational influence holds together galaxies and galactic clusters? What causes the matter-antimatter asymmetry of the universe?

We are searching for possible answers to these questions using precise measurements of atomic spins. Heretofore undiscovered, symmetry-violating interactions could explain dark energy, contribute to dark matter, and generate the matter/antimatter asymmetry of the universe. Such interactions also produce spin-mass and spin-spin interactions that can be searched for in laboratory experiments in a variety of ways. We will discuss (1) recent constraints on such interactions derived from measurements and calculations of electron-mediated nuclear spin coupling in deuterated molecular hydrogen (HD), (2) our ongoing experiment to search for a long-range coupling between rubidium (Rb) nuclear spins and the mass of the Earth, and (3) a new international collaboration, the Global Network of Optical Magnetometers for Exotic physics (GNOME), that will search for correlated transient signals generated by coupling of atomic spins to various exotic particles and fields.