The Most Fun You Can Have With Helium Without Breathing It

Enormous non-equilibrium nuclear-spin polarizations (of order 10%) can be achieved in ^{3}He and ^{129}Xe via spin-exchange optical pumping (SEOP), greatly enhancing the NMR sensitivity of these nuclei. These *hyper*polarized (HP) noble gases are being applied to a broad range of problems in physics, chemistry, and biomedicine, perhaps most dramatically in magnetic resonance imaging (MRI) of the air spaces of the lung, a notoriously difficult organ to image conventionally. The recent strong push in applications of HP gases has created tremendous cross-disciplinary excitement, but has left in its wake a number of important and persistent problems in the physics that must be addressed to realize the full potential of the various applications. After a brief introduction to SEOP and some of the applications (several of which our group is pursuing), I will focus on one particular aspect of HP-gas physics that has concerned us most recently: the interaction of ^{3}He nuclei with surfaces. The understanding of surface interactions is crucial for efficient production and handling of HP gases for experiments such as MRI, since these interactions cause the nuclei to relax back to thermal equilibrium (with characteristic time T_1), destroying their NMR sensitivity. For example, we recently discovered that ferromagnetic sites at or near the glass surface of ^{3}He spin-exchange cells play a key role in surface relaxation. These sites produce hysteresis in measured relaxation times T_1 as a function of the cell's exposure to a magnetic field. In addition to implications for HP-gas production, the exquisite sensitivity of T_1 to the changing magnetic moments of the sites suggests the use of ^{3}He as an inert probe of surface magnetism.