Graduate Student Seminar

APS Practice Session

1) Steve Morgan

Eigenvalues of the time evolution operator governing nuclear spin behavior in solids

STEVEN W. MORGAN, BRIAN SAAM. The decay of nuclear magnetic resonance (NMR) signals in solids is an extremely difficult many-body problem with no complete solution. Utilizing frozen xenon polarized by spin-exchange optical pumping, we have observed the longtime behavior of the transverse NMR signal for both free-induction decay and spin (solid) echoes. The hyperpolarized signal can be observed for up to _10 decay constants, allowing us to characterize the long-time behavior, which is predicted to have one of two forms: S(t) _ e−t or S(t) _ e−t cos(!t+_), where the constants ! and are the same for the FID as for the solid echo. Our data agree well with this prediction, which follows from considering the evolution of the density matrix under the action of its time evolution operator, with the corresponding eigenvalues determining the evolution of the spin system.* Not only is this decay an example of Markovian behavior on non-Markovian timescales but these eigenvalues should be a deep fundamental property of many-body quantum systems. The eigenvalues are also expected to be analogous to Pollicott-Ruelle resonances in classical chaotic systems. *B.V. Fine, Phys. Rev. Lett. 94, 247601 (2005).

2) Ben Anger

Rapid Production of Hyperpolarized ^{3}He Gas for MRI

BENJAMIN C. ANGER, University of Utah, RICHARD E. JACOB, KEVIN R. MINARD, Pacific Northwest National Laboratory, BRIAN T. SAAM, University of Utah | Hyperpolarized (HP) 3He gas created via spin-exchange optical pumping (SEOP) is widely used as a signal source in MRI applications. One drawback to conventional SEOP is the time required for polarization. The process normally requires 10 - 20 hours to achieve 40-50% polarization in enough gas (»1 L) for a single imaging experiment. Two recent advances in the physics of SEOP have led to dramatic enhancements in polarization efficiency: the use of spectrally narrowed diode-laser arrays and hybrid SEOP, which employs both potassium and rubidium as alkali-metal intermediaries. We have combined these techniques in constructing two polarizers, a prototype system at Utah and a more fully engineered system at PNNL. We report >60% 3He polarization in 0.5 bar·L of gas in valved and refillable glass cells, achieved in under 4 h. With the apparatus described we are able to produce several liters of polarized 3He per day.

Tuesday February 27, 2007
11:00 in JFB 206