Please Post

Department of Physics Colloquium

Friday, February 19, 2010 • 4:00 P.M. • 2241 Chamberlin Hall

cookies & coffee served at 3:30 p.m

Turning Photons into Polarized Nuclei

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Spin-exchange optical pumping (SEOP) transfers the angular momentum of circularly polarized light to noble gas nuclei through a series of steps. First, an opaque vapor of alkali atoms (transmission~exp[-100]) is rendered nearly transparent by optical pumping into an atomic dark state with an efficiency of 1 photon per atom. Collisions between the alkali atoms are nearly spin conserving and produce a spin-temperature distribution with a temperature of about -0.06 K, or, in angular momentum units, -0.2 hbar. The highly spin-polarized atoms then transfer their angular momentum to noble gas nuclei through a weak hyperfine interaction occurring in binary collisions or formation of weakly bound van der Waals molecules. The cross sections for this process are tiny by atomic standards, 10^-24 cm^2, but this is compensated for by having an extremely large collision rate and long nuclear spin-relaxation times. According to these arguments, it should be possible to transfer angular momentum from laser light to nuclei with an efficiency of about 25%, producing >95% polarized nuclei. The resulting high density, hyperpolarized noble gas vapors are of considerable interest for medical imaging, spin-polarized targets, neutron spin-filters, and precision measurements.

In practice, the performance of SEOP falls substantially below expectations. When Wisconsin entered the field in the mid '90s, the efficiencies were routinely much less than 1% and the polarizations in the mid 50%s. Through a series of experiments and technological developments, we have increased the efficiencies by an order of magnitude and produced polarizations as high as 80%. This colloquium will describe these experiments and their consequences.