Spin Exchange Optical Pumping

The spin-exchange optical pumping technique involves transferring angular momentum from a circular polarized laser beam to potassium and subsequently to H/D via spin-exchange collisions. The potassium 42P state is excited by a π, photons to the excited 4P state, which decays back to the ground state levels with a branching ratio of 2/3 to m1/2=+1/2 and 1/3 to m1/2=-1/2. A strong holding field (∼10^8 Gauss) defines the axis of polarization and helps to overcome the radiation trapping effect in order to reach high optical pumping efficiency. The spin is transferred to the H/D atoms through spin-exchange collisions with a cross section of 7.4 x 10^-16 cm2.

The H/D nucleus also gets polarized through the hyperfine interaction. In a strong field, the nuclear and atomic spin decoherence, weakening the hyperfine interaction; however, the high H/D density in the spincell increases the number of collisions to compensate, and the system is designed to be in spin temperature equilibrium.

The graph to the left shows the electron and nuclear polarization densities of H/D as a function of the spin temperature in equilibrium. For H, the electron and proton have the same polarization.

Polarizer

The H/D gas is pumped through a 3 mm hole in the side of the storage cell close to the transport tube. A second hole for sample is left close to the center to ensure that the gas is not being directly sampled from the transport tube. The entire polarimeter is mounted to the target chamber through a bellows and gimble mount for alignment. Blank copper gaskets with 3 mm holes in the center are placed between each stage for beam collimation and differential pumping.

Laser Driven Target Results

The final two plots show work in progress for polarization measurements. In each plot, the laser wavelength is scanned over the s_1 and s_2 absorption lines at 770.105 and 770.115 nm. The blue points are the laser transmission through the spincell, and magenta points are the mass 1 signal. The measurements were carried out with a defect voltage preserving mirrors (the circular polarization of the laser light after the periscope was only 88%).