Optical Pumping Labscript

Introduction
Optical pumping is a technique whereby light can be used to create nonequilibrium occupation of atomic levels. Due to the coupling between electron and nuclear spin via the hyperfine interaction, the technique is also of great current interest because it provides a means of achieving preferential nuclear spin polarization of atoms in a gas (it can also be done for semiconductors) This lab will challenge your knowledge of quantum physics of atomic systems.

Background
Read the article by Butcher et al.
Review the TeachSpin manual.
Both are available in the course website.

Experiments

Perform experiments A-D from the TeachSpin manual.
See below for notes:

Notes on optical pumping experiments:

IMPORTANT: It is very important to ensure that the apparatus is located far from any strong magnetic fields. The area should be checked with the supplied dip needle to make sure that it is appropriate

4A. Absorption of Rb

Only do a maximum of 4-5 measurements since each measurement will take ~30 min for thermal equilibrium.

4B. Low Field Resonances

Note: make sure to read chapter 5 (check this) before starting the labscript 4B. This has important tips on how to observe the zero field resonance.
Do not use the 4 MΩ gain setting on the photodetector. It has significant 60 Hz noise. Use 1 MΩ for large signals and 10 MΩ for small signals. For a signal that is too small for 1 MΩ and too big for 10 MΩ, use the 10 MΩ setting and attenuate the signal using two linear polarizers. It is important that when you use the second polarizer you do not change the orientation of the linear polarizer directly in front of the circular polarizer. The linear polarizer directly in front of the quarter wave plate must remain at 45º and the quarter wave plate should be set at 0º for circularly polarized light.

If the noise is still too large after doing the above, one can reduce the noise by increasing the time constant of the detector. Remember, when doing this that the signal will respond more slowly to changes if the time constant is large. In practice, it is best to remove noise using as small a time constant as possible so you can see variations that happen quickly.

On page 4-8 it states “Disconnect the main field coils”. What it should say is disconnect the horizontal main field coil. The vertical main field coil should not be disconnected or the zero field resonance width will mask the other signals.

On page 4-8 it states “An oscilloscope should be used to measure a signal proportional to the RF current”. This measurement can be made at small connections on the front of a box at the side of the cell. The connections are a tab and a knob.

To record the oscilloscope readings it is best to use the run/stop button and then save as a spreadsheet.

4D. Transient Effects

For this measurement it is best to use the 10 MΩ detector setting with two linear polarizers and the min time constant.