Improving Laser Guide Stars through Magnetic Resonant Pulsing

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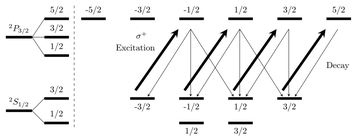
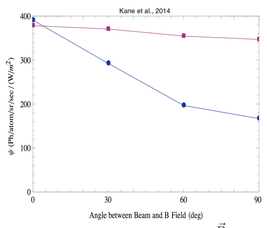
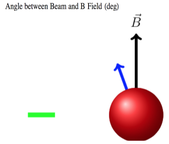
Introduction

Laser guide stars (LGS) are artificial stars created in Earth's atmosphere that aid in reducing blur from atmopheric distortion in telescopic imaging. Increasing the brightness of LGS improves the ability of the telescope system to reduce blur. Thus, LGS systems typically use high power laser beams. At high power, the polarization of light becomes an important factor in the LGS's brightness, and circular polarization creates the greatest brightness. However, this leads to optical pumping, which reduces the brightness due to the precession of atoms in the geomagnetic field. A solution to this is magnetic resonant pulsing (MRP).

Magnetic Resonant Pulsing





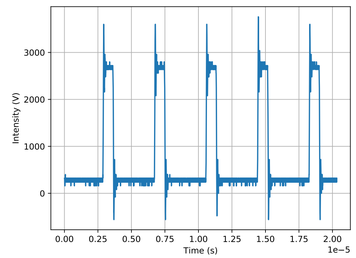


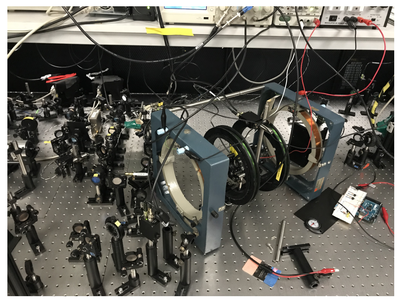
The cycling transition normally established in the absence of a magnetic field is disrupted when the magnetic field is not parallel to the incoming light. This causes fluorescence to decrease as a non-optimal distribution of angular momentum occurs. By pulsing light at the Larmor frequency, the atom is essentially is not precessing with respect to the light, and the cycling transition is maintained.

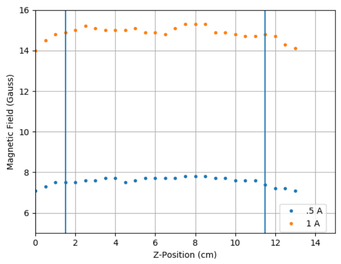
Experimental Set-up

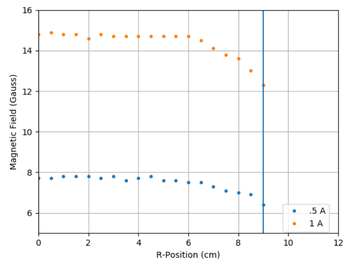
A pulsed laser was created with a diode laser ($\lambda = 780$ nm) chopped by an acousto-optic modulator (AOM). The pulse width and repetition rate were controlled with a function generator connected to the AOM.

Two Helmholtz coil configurations were used, one to rid the system of external magnetic fields and the other to produce a constant magnetic field that could be rotated with respect to the laser beam. The strength of the magnetic field inside the coils was measured as a function of position to ensure homogeneity within the system.



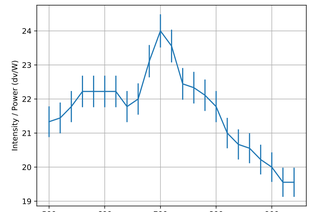


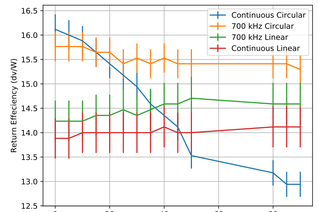




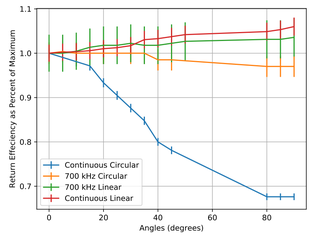
Results

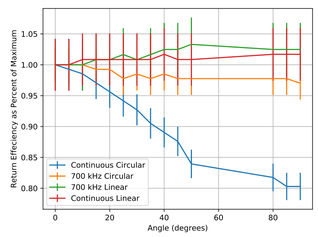
A clear increase in fluorescence at the Larmor frequency can be seen when the magnetic field is perpendicular to the laser beam. The fluorescence of rubidium atoms is shown to stay constant over all magnetic field angles with a pulsed laser as opposed to decreasing with a continuous laser.





The percent change in fluorescence shows, for high intensity laser beams, that the fluorescence from continuous light decreases by roughly 30% and, for low intensisites, 20%.





Future Work

- Look at using a repumping laser in order to counter the negative effects of downpumping present in the high intensity case.
- Create pulsed laser with lower duty cycle, and find optimal duty cycle that results in highest fluorescence.

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