Control of intensity drive of a Cavity QED system.

J. O. Gómez Muñoz [1,2], B. D. Patterson[1], A. D. Cimmarusti[1], W. M. Pimenta[1,3], and L. A. Orozco[1].

[1]Joint Quantum Institute, Department of Physics and NIST, University of Maryland, College Park, MD 20742, USA.

[2] Facultad de Ciencias,Universidad Nacional Autónoma de México, Instituto de Ciencias Nucleares, México, DF, México.

[2] Departamento de Fisica, Universidade Federal de Minas Gerais, Bello Horizonte, Brazil.

Motivation

Our experiments with low photon number in a two-mode optical cavity require having optimal control of our driving laser intensity. We use an Arduino Uno, an H bridge, PRM1Z8 Motorized Rotation Stage together with a half wave plate to reduce the power fluctuations of the main drive over time with feedback. We use a Proportional Integral and Differential (PID) loop implemented on the Arduino's code to sample and correct for low frequency intensity fluctuations. The resulting normalized variations decrease by a factor of three as measured off-loop when the PID is working.

Cavity QED system

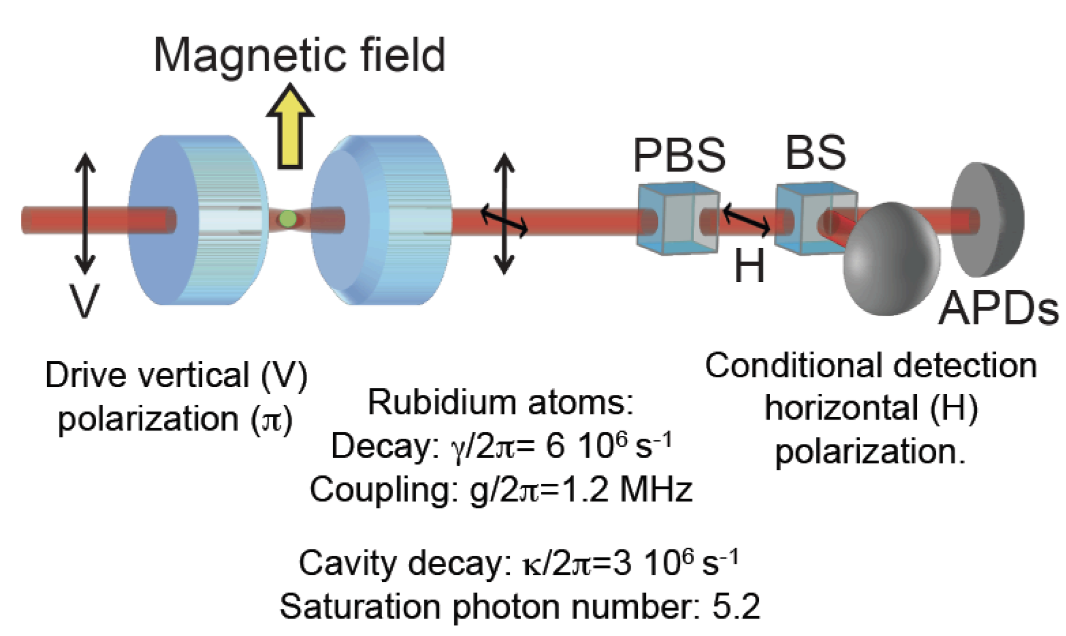


Fig. 1 Cavity QED system showing the main parts of the experiment

Cavity QED studies the interaction of an atom with a single or a pair of modes of the electromagnetic field. We use an optical cavity with separation of 2 mm and Finesse of 12,000 to study the interaction of a cold Rb beam that crosses the mode of the cavity and remains in the cavity for about 5 µs (about 200 atomic lifetimes). The atoms are externally driven and through conditional measurements they end in a ground state superposition of two Zeeman sublevels. The superposition evolves and manifests itself in a conditional ground state quantum beat.

This six-level system realizes a "quantum eraser" that removes the distinguishability of the intermediate ground states.

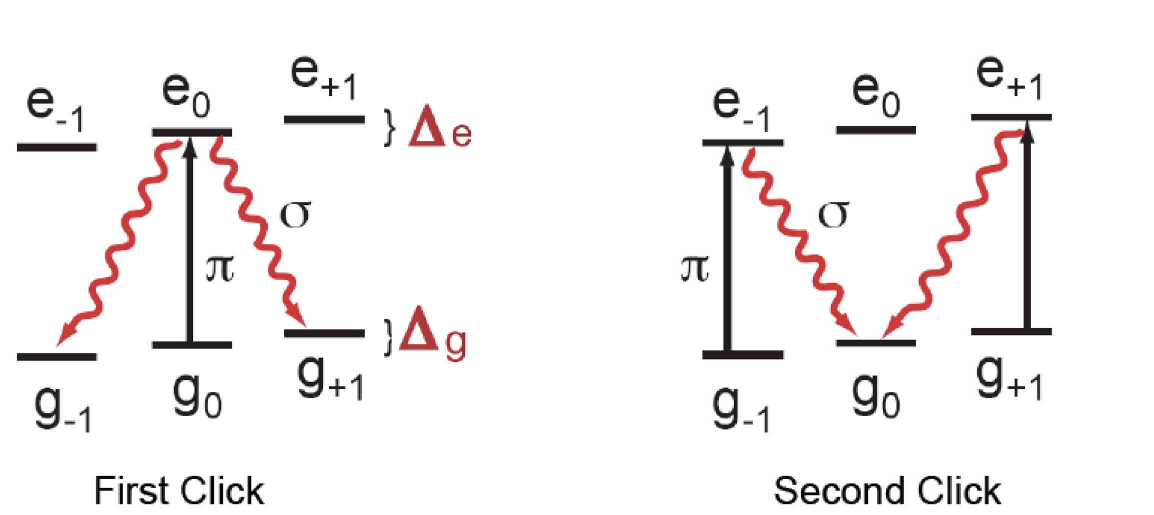
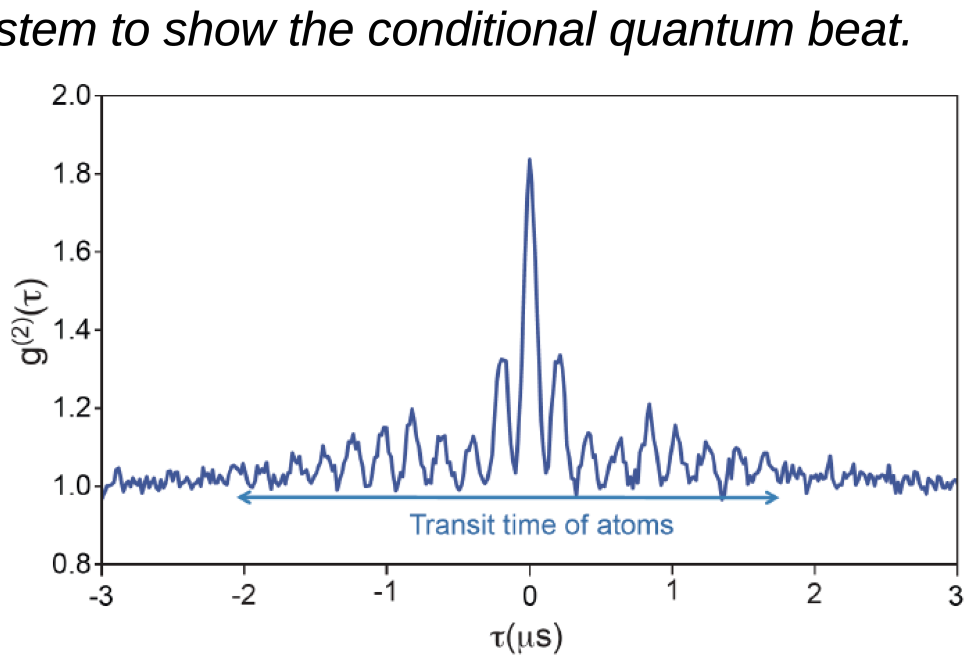


Fig. 2 Schematic of energy levels that enter in the system to show the conditional quantum beat.



Firg 3 Conditional intenstity showing beats..

Problem and method to solve it

We need to keep the drive constant to a fraction of a percent. The light gets to the Cavity QED system thorough single mode fibers that are polarization preserving. Those fibers can change from temperature and stress so an active way to align the polarization with the fiber is necessary. We have used a motorized half wave plate to align the incident polarization with the fiber and use a PID control system implemented in a stand alone card (Alduino) to perform the feedback.

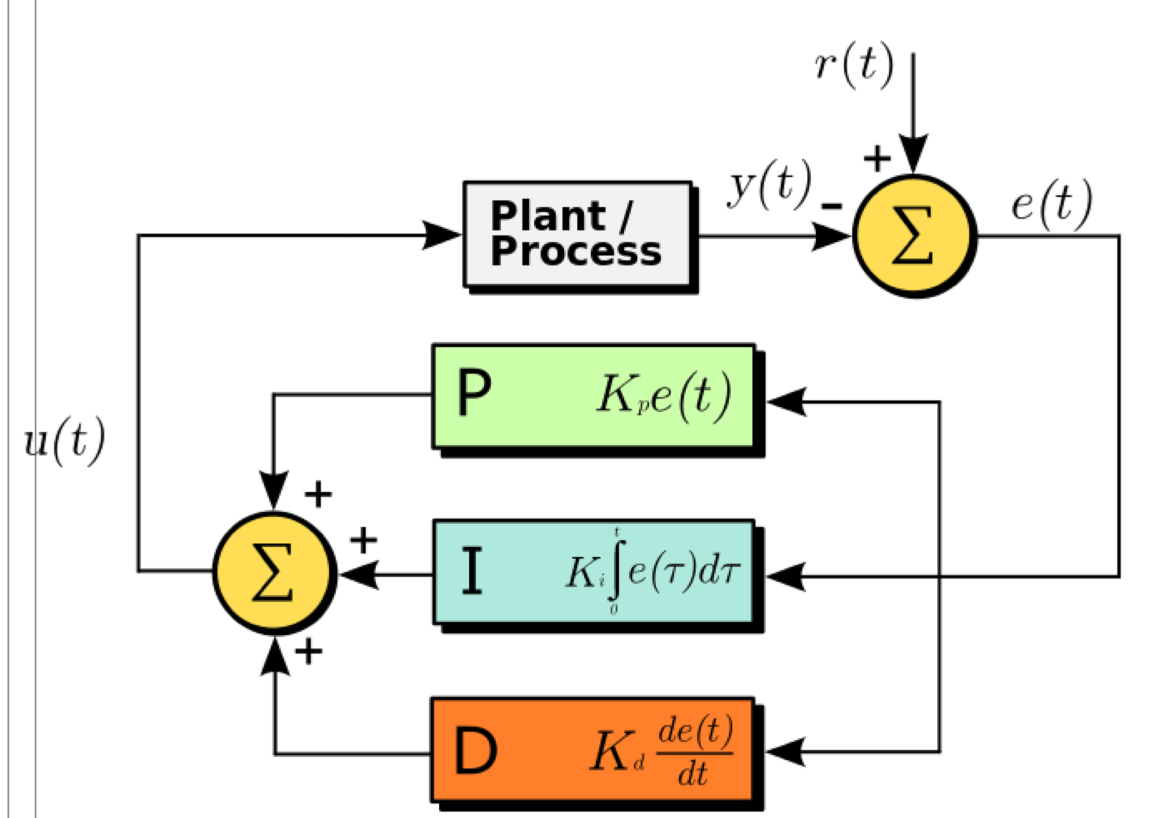


Fig 4. Schematic of a PID control system

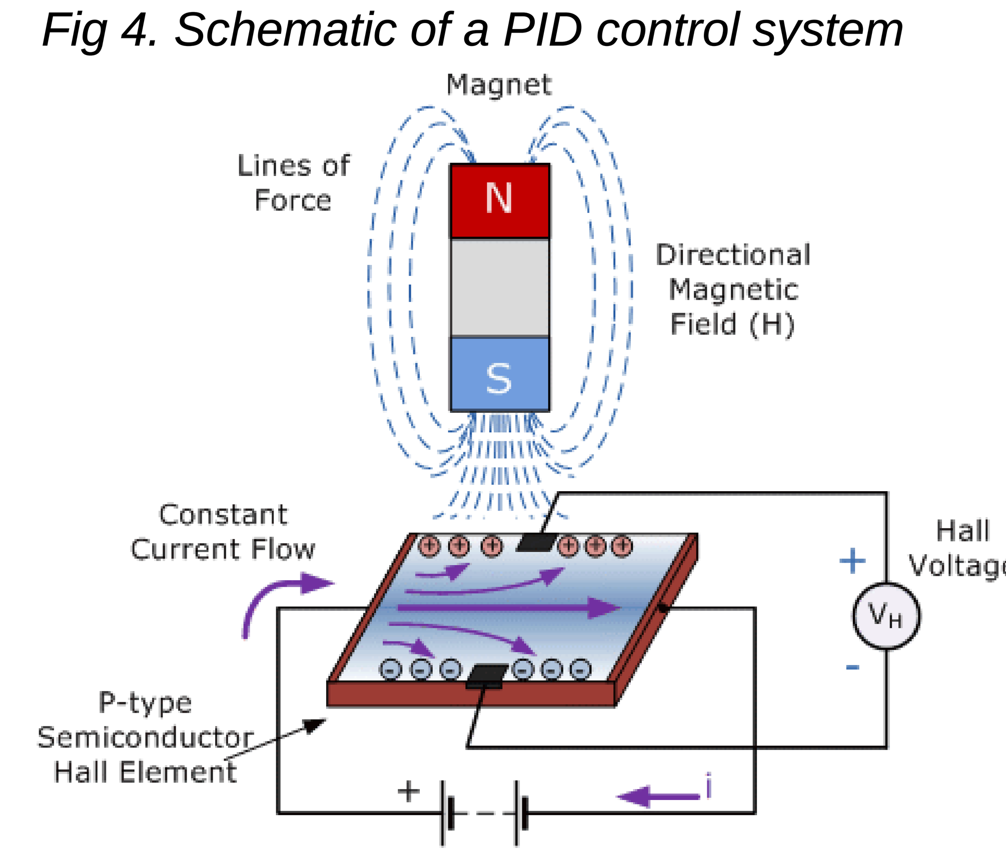


Fig. 5 Motorized Rotation Mount principle.

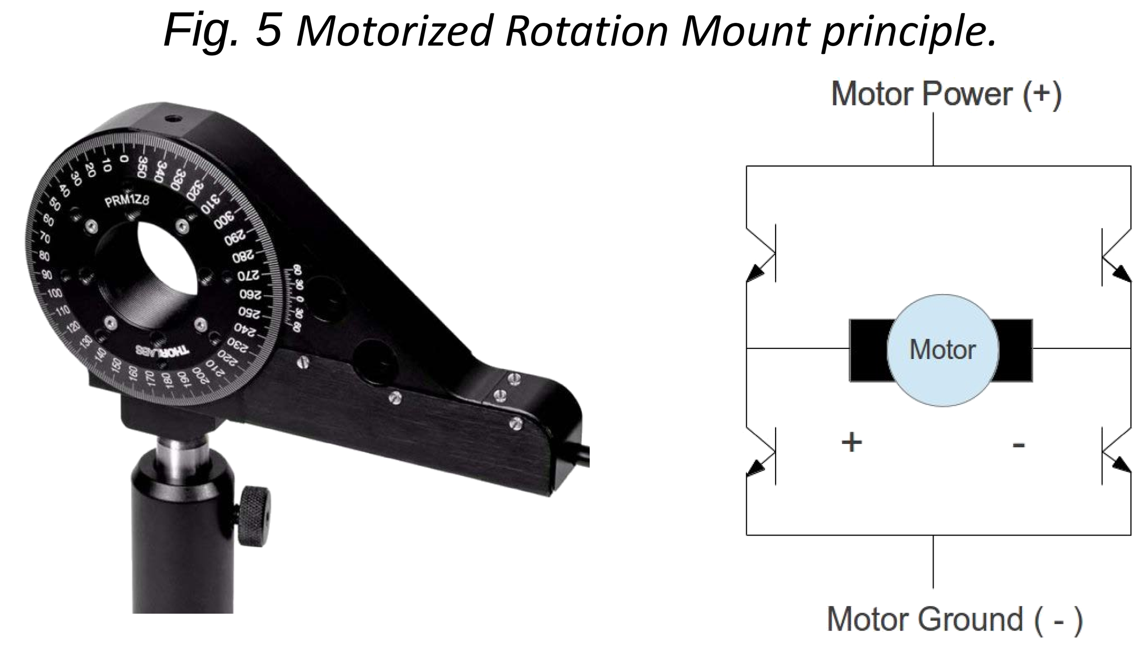


Fig. 6 Thorlabs rotation stage and electric diagram.

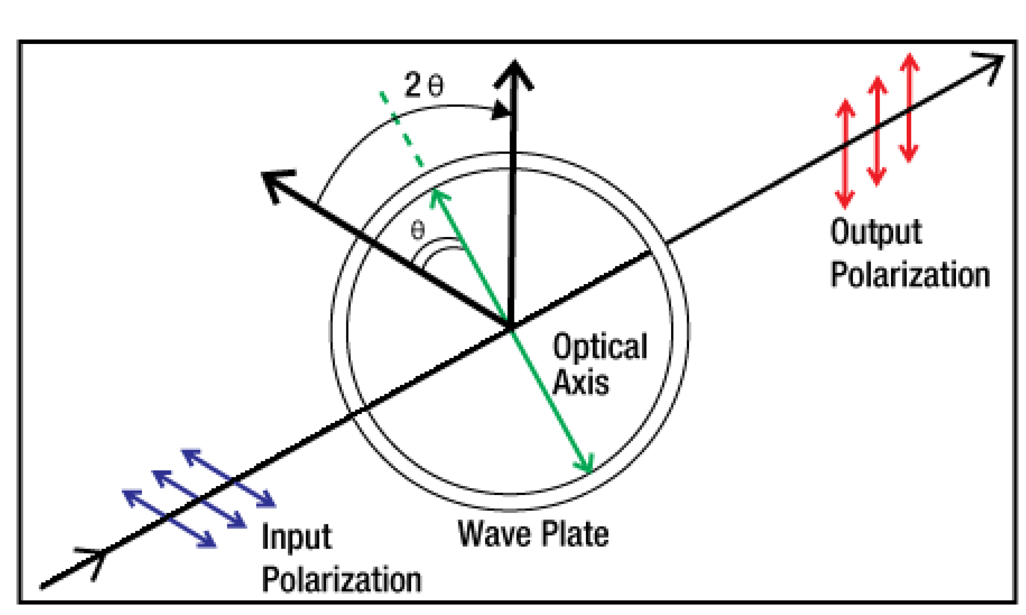


Fig. 7 Optical polarization through a waveplate.

Results

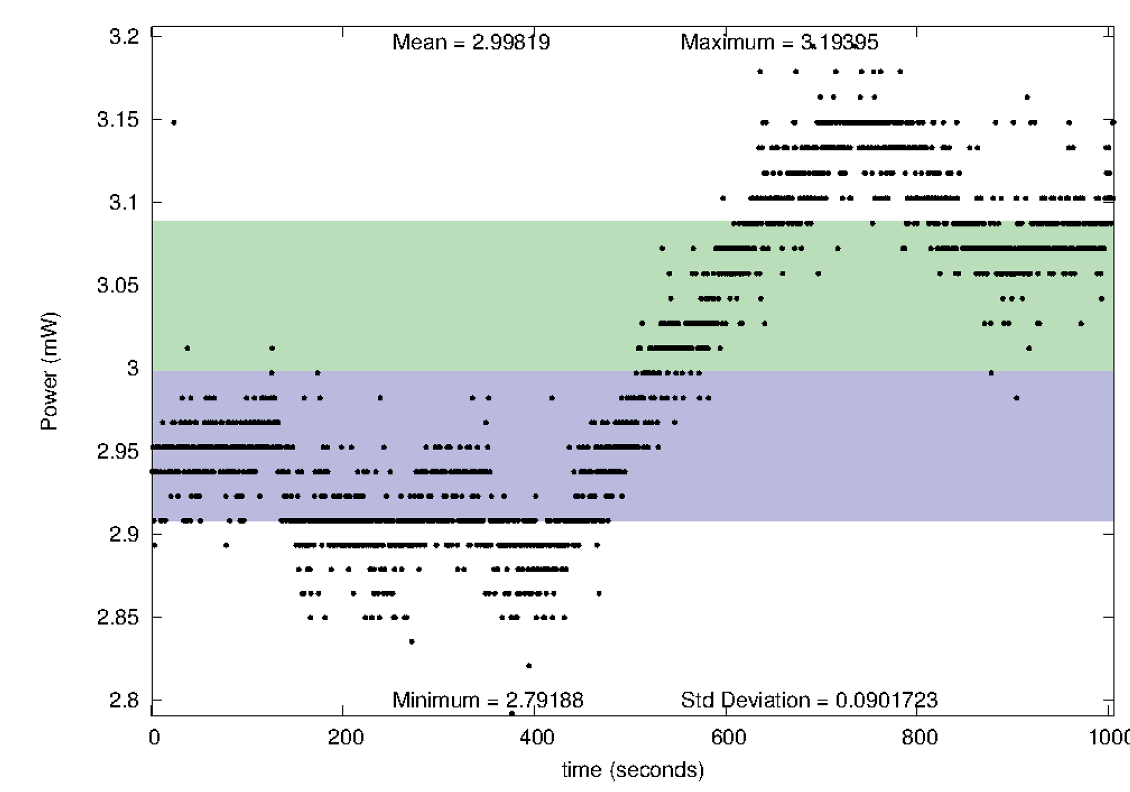


Fig. 7 Intensity fluctuations over 1000 s free running.

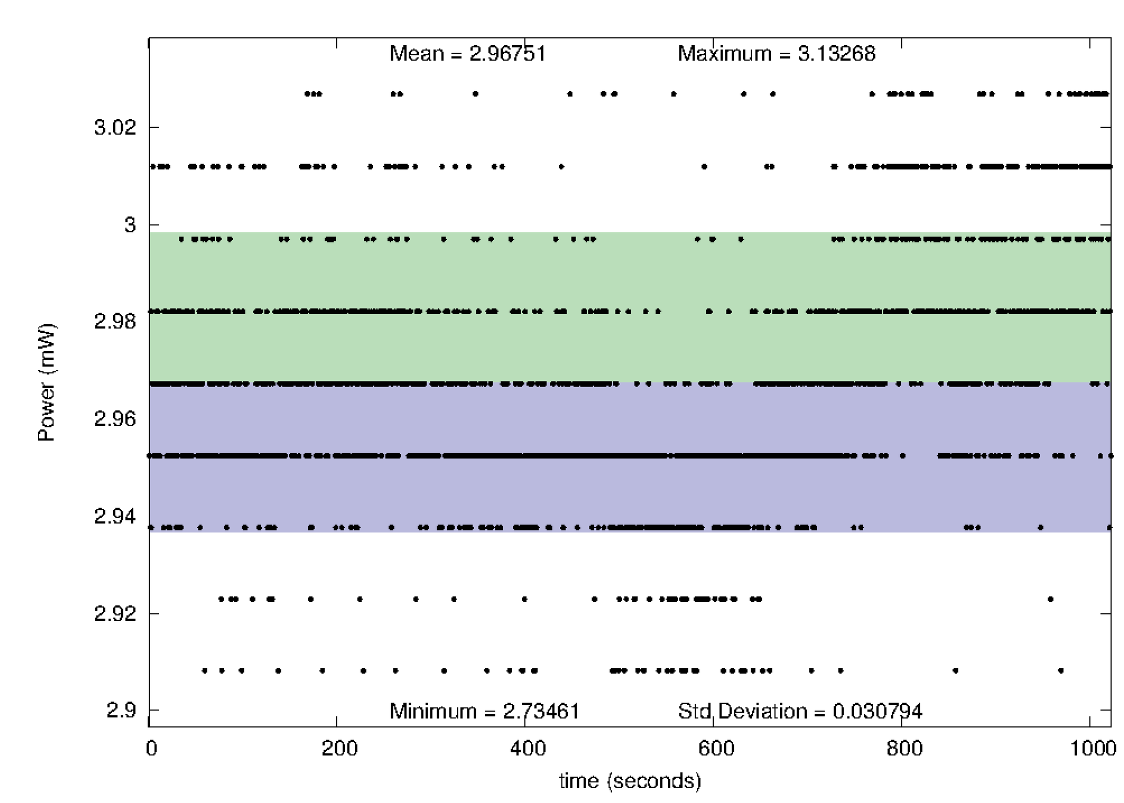


Fig. 8 Intensity fluctuations over 1000 s with feedback loop closed. Measured with an independent meter.

Conclusions

We were able to reduce the fluctuations of the light using the feedback loop by a factor of 3.7 as measured by the coefficient of variation defined as the ratio of the standard deviation divided by the mean.

The former is crutial for making the experiment more stable. Other systems will be stabilized next.

References

A D Cimmarusti, C A Schroeder, B D Patterson, L A Orozco, P Barberis-Blostein and H J Carmichael. "Control of conditional quantum beats in cavity QED: amplitude decoherence and phase shifts". New J. Phys. **15,** 023002 (2013)**.**

Mikhailov, Eugeny E. College of William & Mary. "Chapter 11 Feedback and PID Controll Theory". As dowloaded on August 4, 2013 http://physics.wm.edu/~evmik/classes/2011_spring_Physics_252_Analog_Electronics/#toc25

Thorlabs. "PRM1Z8 Motorized Rotation Stage Manual". As downloaded on August 4, 2013. http://www.thorlabs.com/Thorcat/19700/PRM1Z8-Manual.pdf

Work supported in part by NSF 0969257, and the JQI.

TREND 2013

Training and Research Experiences in Nonlinear Dynamics

REU program sponsored by the National Science Foundation Award Number: PHY1156454