

**Stony Brook University
The Graduate School**

Doctoral Defense Announcement

Abstract

Optical Forces on Metastable Helium

By

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Optical forces using lasers allow precise control over the motion of atoms. The bichromatic optical force (BF) is unique in its large magnitude and velocity range, arising from the stimulated absorption and emission processes. The finite velocity range of the BF allows estimation of the characteristic cooling time which is independent of the excited state lifetime, only depending on the atomic mass and optical transition energy. Past experiments have demonstrated that the BF can collimate and longitudinally slow atomic beams, but required long interaction times that included many spontaneous emission (SE) events. The effect of SE can be mitigated, and is predicted to not be necessary for BF cooling. Since the BF cooling time is not related to the excited state lifetime, a transition can be chosen such that the cooling time is shorter than the SE cycle time, allowing direct laser cooling on atoms and molecules that do not have cycling transitions. I will present experiments on the metastable helium 2^3S-3^3P transition where the BF cooling time (190ns) is shorter than the SE cycle time (214ns). Numerical simulations of the experimental system predicting compression of the velocity distribution will also be presented. Our experimental results demonstrate the stimulated nature of the force through many atomic recoils from the light in less than one SE cycle time. A large range of the atomic velocity distribution is accelerated and accumulates at the velocity limit of the force. This accumulation results in an increase in the velocity space density, demonstrating cooling.

Date: November 21, 2014

Time: 10:00AM

Place: Physics, S-141

Program: Physics

Dissertation Advisor: Harold Metcalf