Towards Precision Measurement of Pb Scalar Polarizability in an Atomic Beam

Robin Wang '24, Saad Waheed '25, John Lacy, Prof. Tiku Majumder

Department of Physics, Williams College

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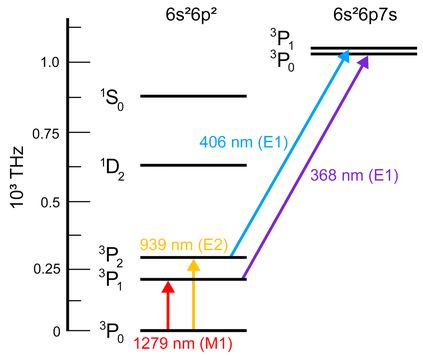
Background

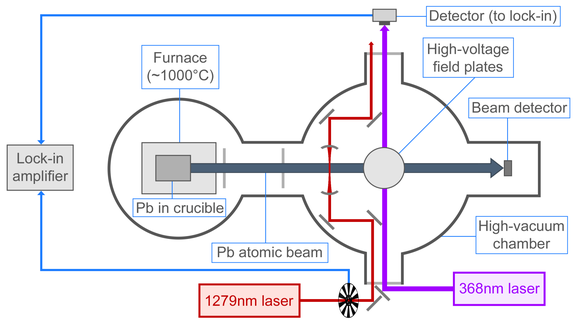
Goal: precision measurement of Stark shift in lead atoms under high electric field to determine scalar polarizability, never previously measured in lead



Low-lying energy levels and relevant transitions in Pb-208

- Heavy multivalence atoms are difficult to model and are good tests for fundamental physics
- Precise experimental measurements test *ab initio* atomic theory (collaborations with Safronova group, U. Delaware)
- Currently investigating 368nm E1 transition Stark shift

Atomic Beam Apparatus

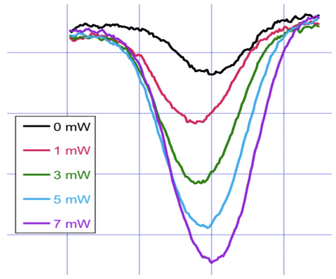


Top-view schematic of atomic beam apparatus with enhancement cavity

- Apparatus previously used for precision measurements of atomic polarizability in In and Tl (Group IIIA)
- Transverse laser beam → Doppler-narrowed atomic signal
- Well-known E-field in interaction region

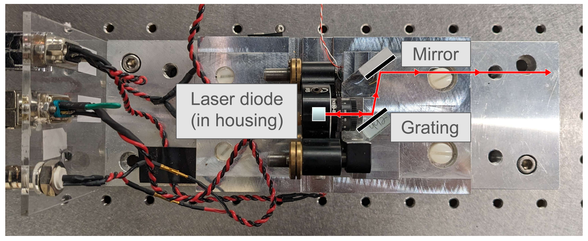
Enhancing $^3P_1$ Population

- In the atomic beam, $^3P_1$ population reduced by factor of 10^4 (compared to vapor cell) and thermally unfavorable → 1279nm M1 pre-pumping
- For a stable $^3P_1$ population, lock M1 laser using FM spectroscopy techniques to eliminate frequency drift



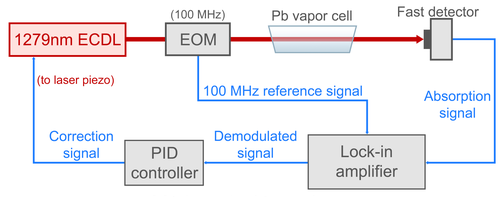
M1 enhancement for 368nm E1 transition, demonstrated in vapor cell

M1 Laser and Locking

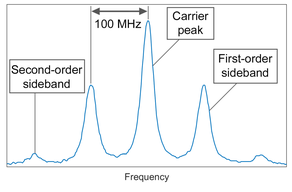


Top view of 1279nm ECDL with labels

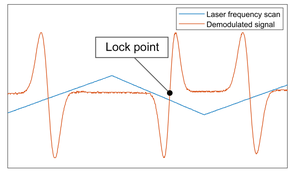
- Build 1279nm external-cavity diode laser (ECDL)
- Use atomic sample (Pb-208 vapor cell) as locking reference



M1 laser locking scheme



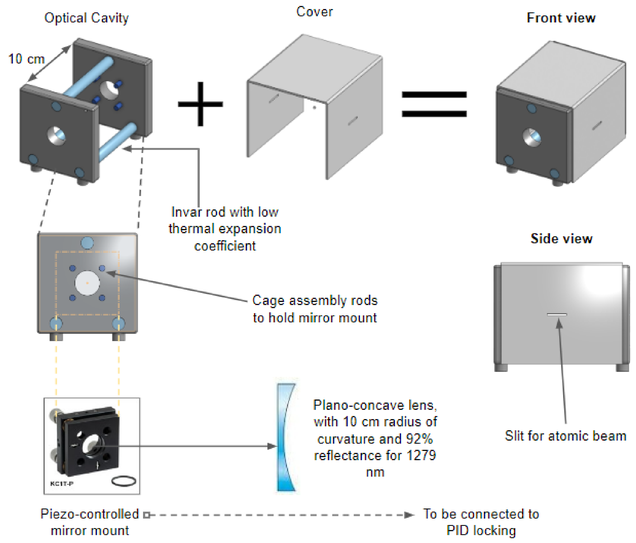
Fabry-Pérot signal for modulated laser



1f demodulated atomic signal

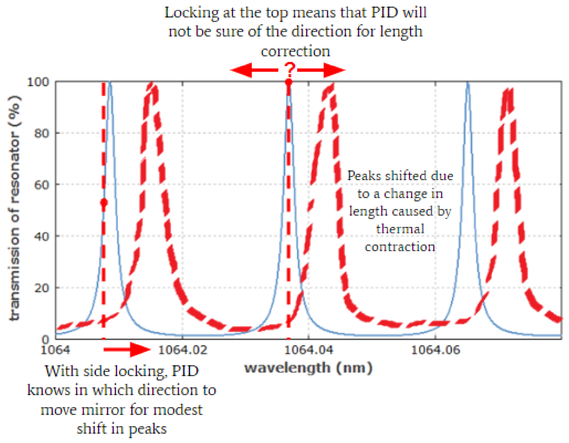
M1 Pre-Pump Optical Cavity

- M1 transition weak → several passes through laser light needed to pump enough atoms to $^3P_1$ → optical cavity



Cavity design

- Despite invar rods, cavity length still sensitive to temperature fluctuations → PID locking to make fine adjustments to piezo-controlled mirror
- "Side" locking despite power losses:



Motivation for side locking