Generation of a cold atom beam from a pyramidal magneto-optical trap

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Introduction

Techniques to generate cold atom beams are of great interest in a variety of applications, from atomic frequency standards and atom optics to experimental studies of Bose-Einstein condensation. Cold atom beams have been produced by slowing thermal atomic beams using the Zeeman-slowing technique [1] or chirped lasers [2], or using laser-cooling techniques to extract a slow atomic beam from the background gas in a low-pressure vapor cell. These laser-cooling techniques include "atomic funnels" or two-dimensional magneto-optical traps [3–5], as well as a variation of the conventional vapor cell magneto-optical trap called the "low-velocity intense source" (LVIS) [6].

Variations of the LVIS have been realized with unique trap geometries such as conical [7] or pyramidal mirror traps [8]. The present work implements a simple and robust design based on the pyramidal trap geometry (Fig. 1) and allows use of a single large diameter (≤20 cm) laser beam to obtain large capture rates of atoms from the background vapor. The four 45° mirrors are truncated just before the apex of the pyramid, and the 1 cm^2 region at the center of the incident laser beam is retro-reflected by a $\lambda/4$ plate with a high-reflectance gold coating on the second surface. A small (1 mm diameter) hole in this retro-optic forms an extraction column for the atoms while maintaining a low conductance between the source region and an adjacent UHV chamber.

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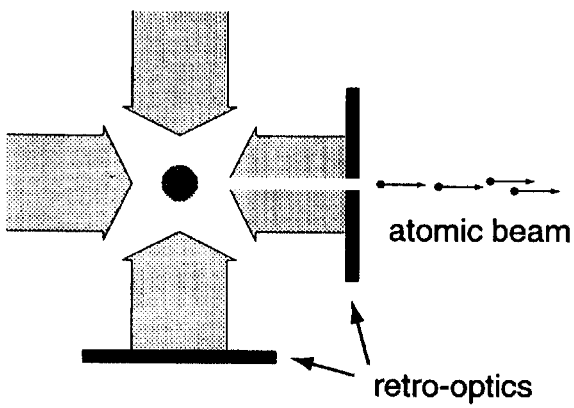
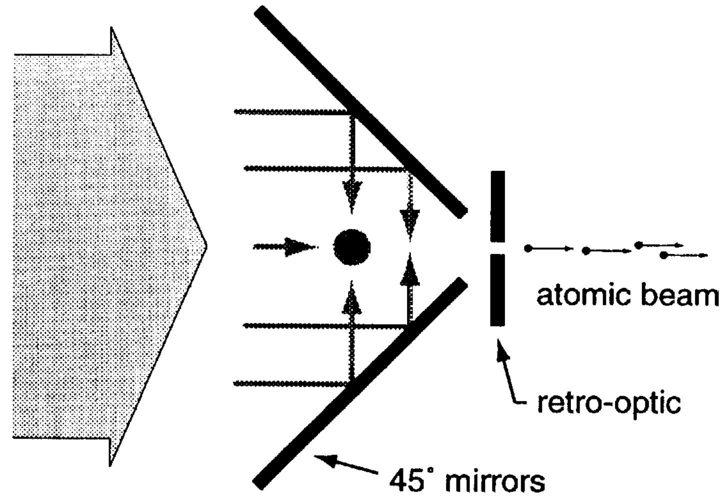
The characterization of this large pyramidal LVIS will be reported, including an investigation of scaling to very large ($\geq$10 cm) high power (~1 W) laser beams which should allow an improvement by a factor of 2–3 in beam flux over previous reports [6]. An atomic beam source which employs Ioffe-Pritchard coils and the same optical geometry to provide transverse two-dimensional confinement within a three-dimensional optical molasses [5] is also being implemented and will be described for comparison.

Low Velocity Intense Source



LVIS



P-LVIS

Lu, *et al.*, Phys. Rev. Lett. **77**, 3331 (1996):

- $v_z = 14 \pm 2.7$ m/s
- flux: 10^9–10^{10} atoms/s
- divergence: 5 mrad (~20 μK)
- brightness: 5×10^{12} atoms/s sr

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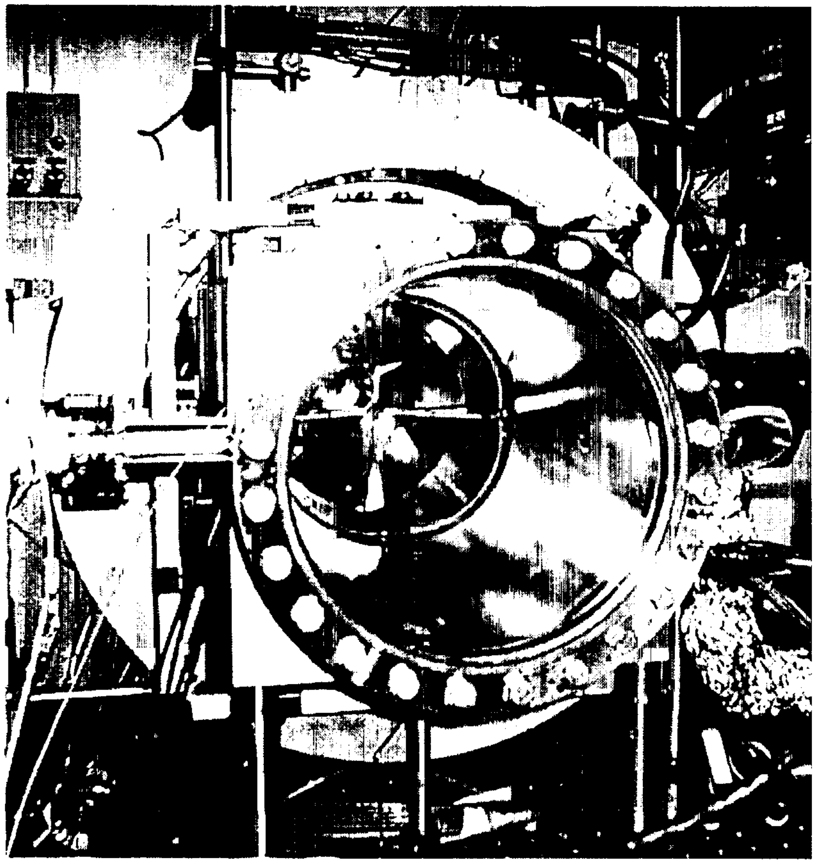
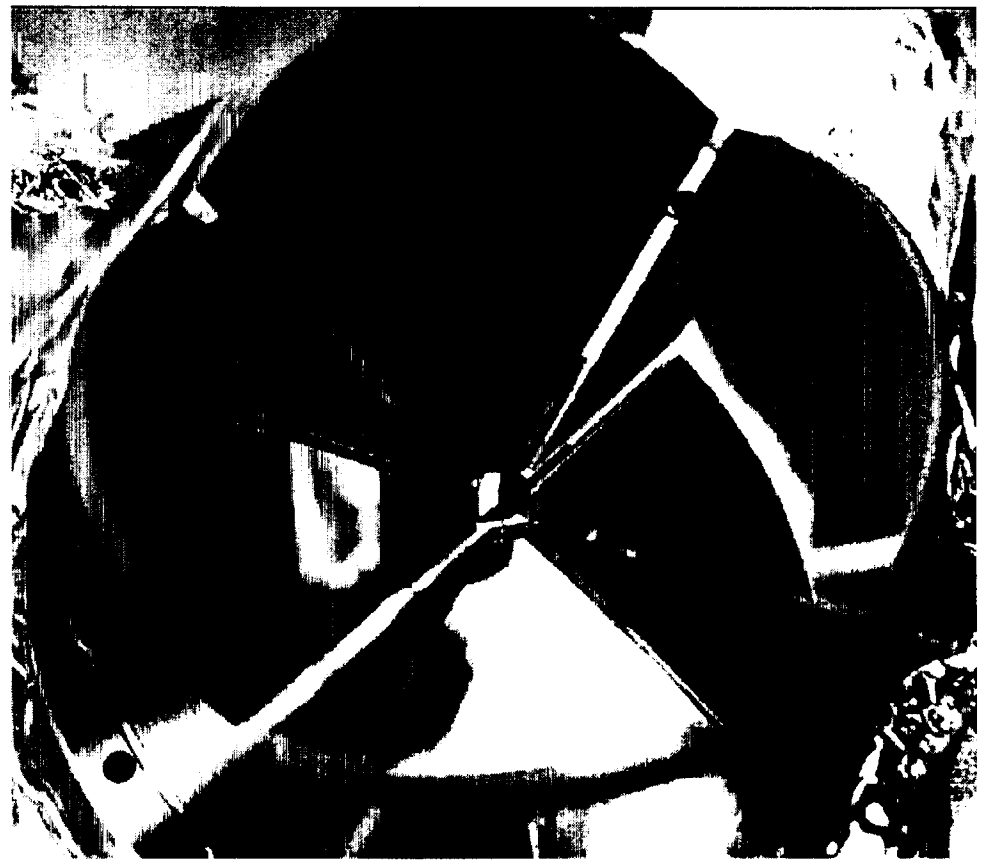


P-LVIS chamber and external coils.



Pyramidal mirror assembly.

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Fluorescence image of trapped Cs atoms in pyramidal MOT.

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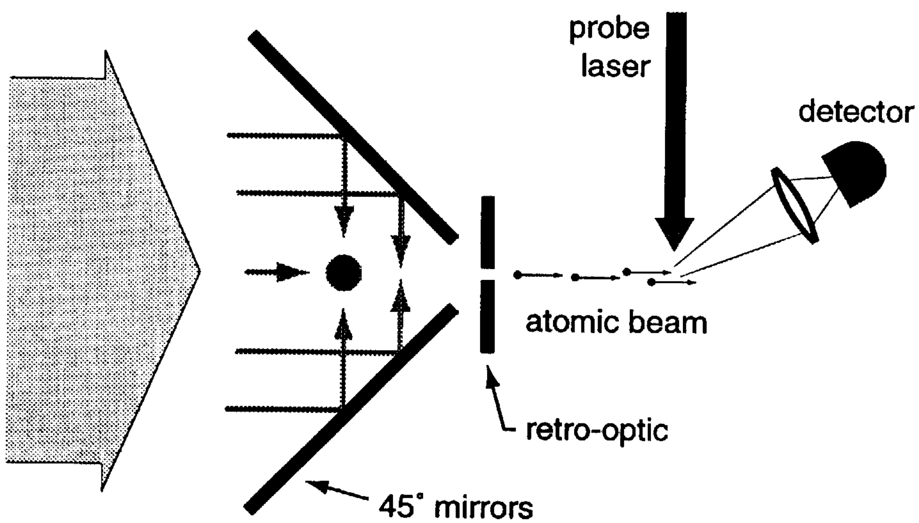
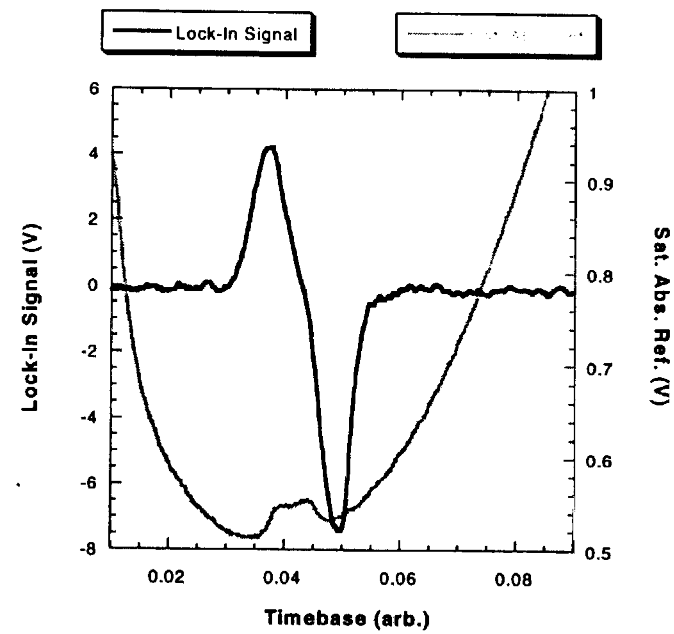
Atomic beam detection





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Low Velocity Intense Source: Further work & applications

Beam characterization

- Beam flux, longitudinal velocity & divergence ...
- **2D-MOT** *vs.* **LVIS** geometry* — optimize flux & brightness
- Loading efficiency into UHV MOT, optical molasses

Future applications

- Evaporative cooling & BEC
- Load optical molasses from beam to enhance cold atom source for clocks

* Dieckmann, *et al.*, Phys. Rev. A **58**, 3891 (1998)

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