Collimation of Laser Light for the Adiabatic Rapid Passage (ARP) Optical Force

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Optical Forces and ARP

Optical forces are imparted on atoms by the processes of absorption and emission. The dependence on spontaneous emission to return the atoms to their ground states limits the strength of these forces, and so stimulated-emission is often used to speed up this transition.

Adiabatic rapid passage (ARP) is a technique used for the inversion of a two-level spin system which gives greater control over the absorption and stimulated emission processes. ARP uses discrete pulses of light that have a continuous sweep in frequency to invert states with very high efficiency.

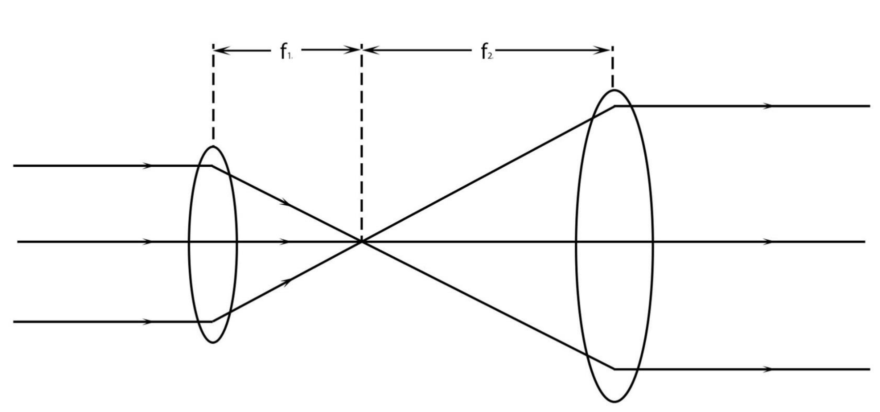
Interaction time between the light and the atoms must be controlled, so we block the edges of the laser beam while simultaneously mitigating the effects of diffraction. We can vary the beam width to control the time.

Shaping of the Laser Light

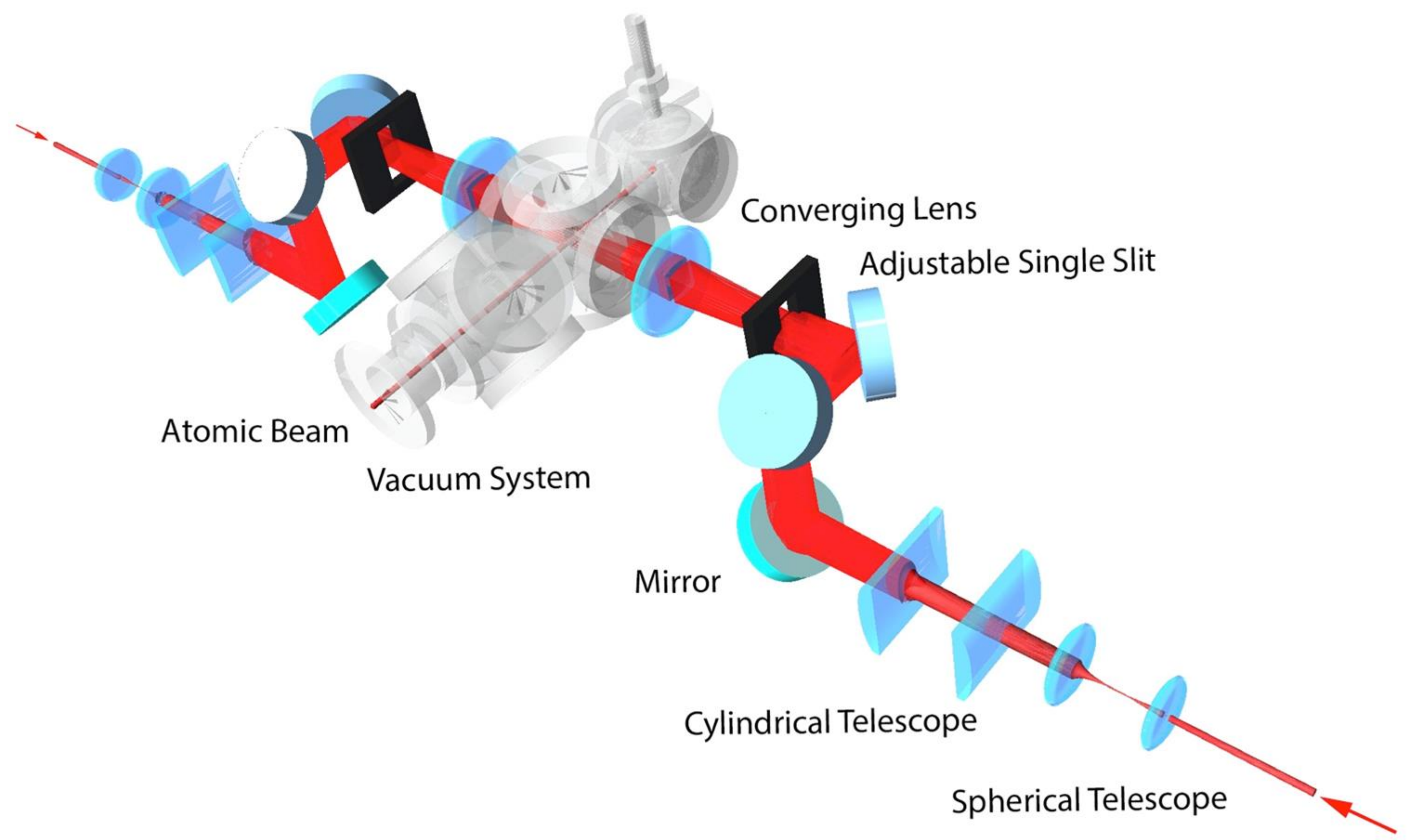
We require two identical, counter propagating laser beams to be crossed perpendicularly by an atomic beam that is formed in a vacuum system.

Two telescopes are used in each collimation line. A spherical telescope magnifies the beam emitted from transporting optical fibers and a cylindrical telescope magnifies this beam in a single dimension for our desired shape of 2mm x 6mm. To control interaction time, a variable slit placed at the end of the lines cuts off the edges of the beam's Gaussian profile.

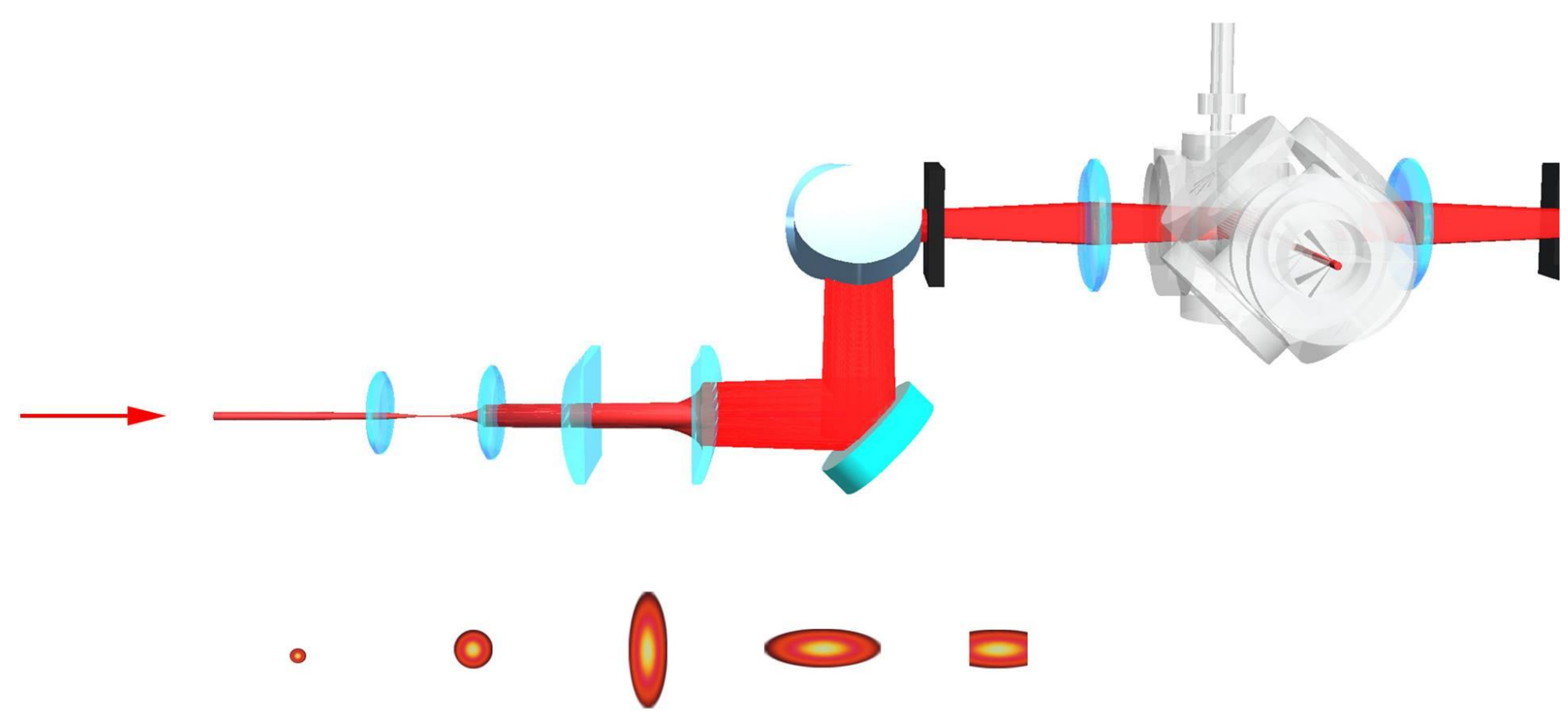
A shearing interferometer was used to measure, approximately, the quality of collimation and a beam profiler was used to make micrometer level measurements of the beam width and shape for finer tuning of the lens positions.



Ray diagram of the beam magnification through the spherical telescope.



Laser light from two identical collimation lines enters the opposite sides of the vacuum system perpendicular to the atomic beam of helium.

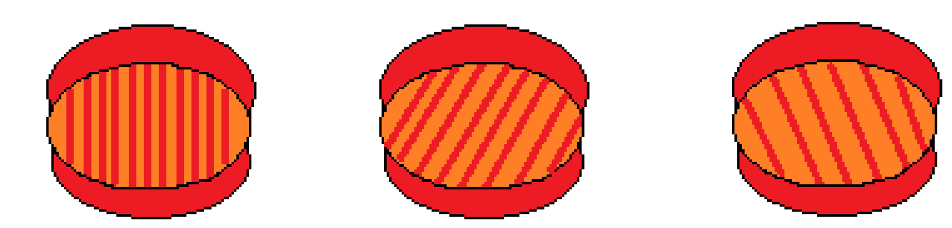


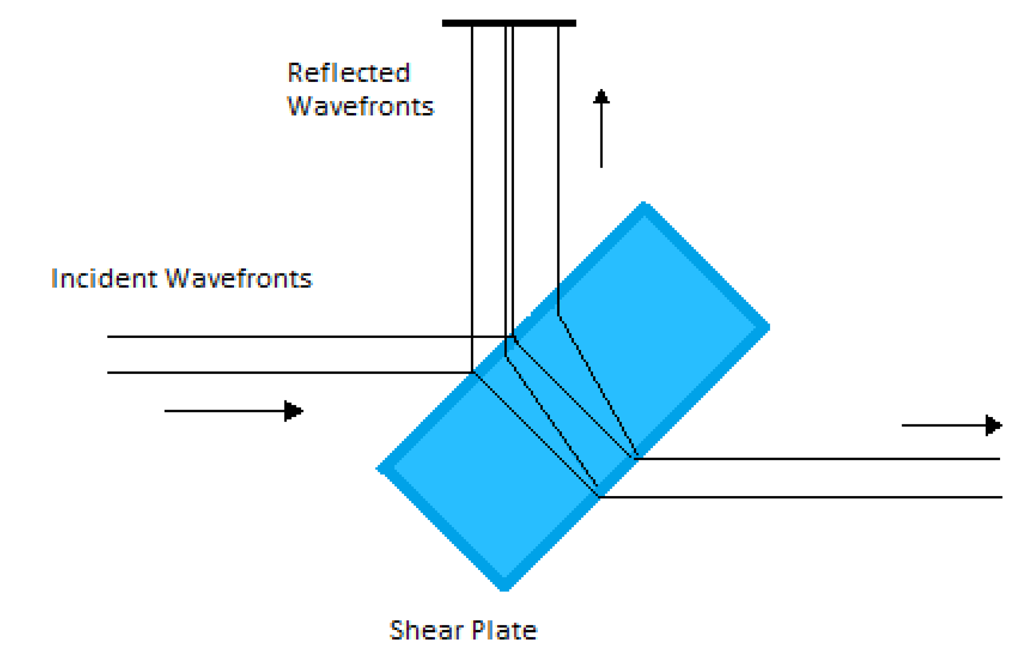
From left to right:

- Amplified laser light is emitted from an optical fiber
- The beam is magnified by the spherical telescope , consisting of a 20mm and 80mm lens, to a diameter of 2mm
- The cylindrical telescope, consisting of a 25mm and 75mm lens, magnifies the beam in one dimension
- Mirrors properly orient the beam by rotation
- A variable slit cuts off the lower intensity wings
- A converging lens images the slit into the vacuum chamber

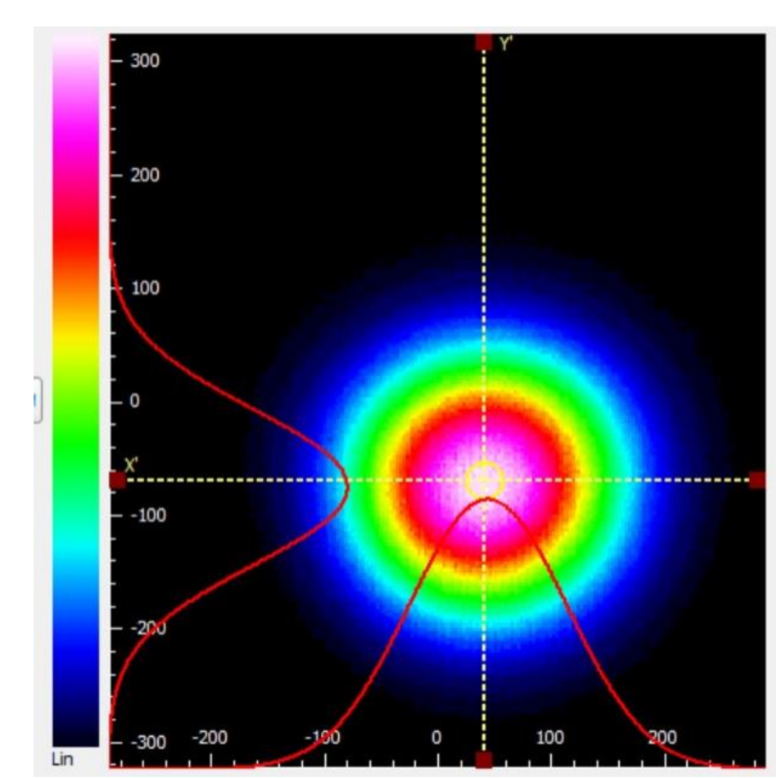
Shearing Interferometer and Beam Profiler

After positioning the two lenses of either telescope, the shearing interferometer was placed in the resulting beam. Reflections from the front and the back of the shear plate interfere, and the resultant pattern can be used to determine whether the coherent light is converging, diverging, or collimated.





After the interferometer successfully confirmed collimation of the beam, a CCD beam profiler was placed at different positions along the traveling direction of the beam in order to measure and record the width of the beam. A zero or near-zero slope indicated collimation of the beam.



Two dimensional Gaussian profile reading

Acknowledgments

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