Analysis of a Cat's Eye Retroreflector Using a He-Ne Laser

Marcus Lo, Raffaele Miceli, Grant Richmond, Max Stanley, Harold Metcalf

Stony Brook University-Department of Physics and Astronomy

INTRODUCTION

Diode lasers are low cost and compact compared to other lasers types, but their light is usually highly divergent and sensitive to small misalignments and mechanical disturbance. Creating an external cavity with a cat's eye reflector and controlled output gives a more stable cavity.

The cat's eye retroreflector gives very good angular stability especially when well aligned. The effects could likely be improved by using a larger lens with a more well defined focal point. In doing this an ordinary diode laser could be changed into a research quality laser.

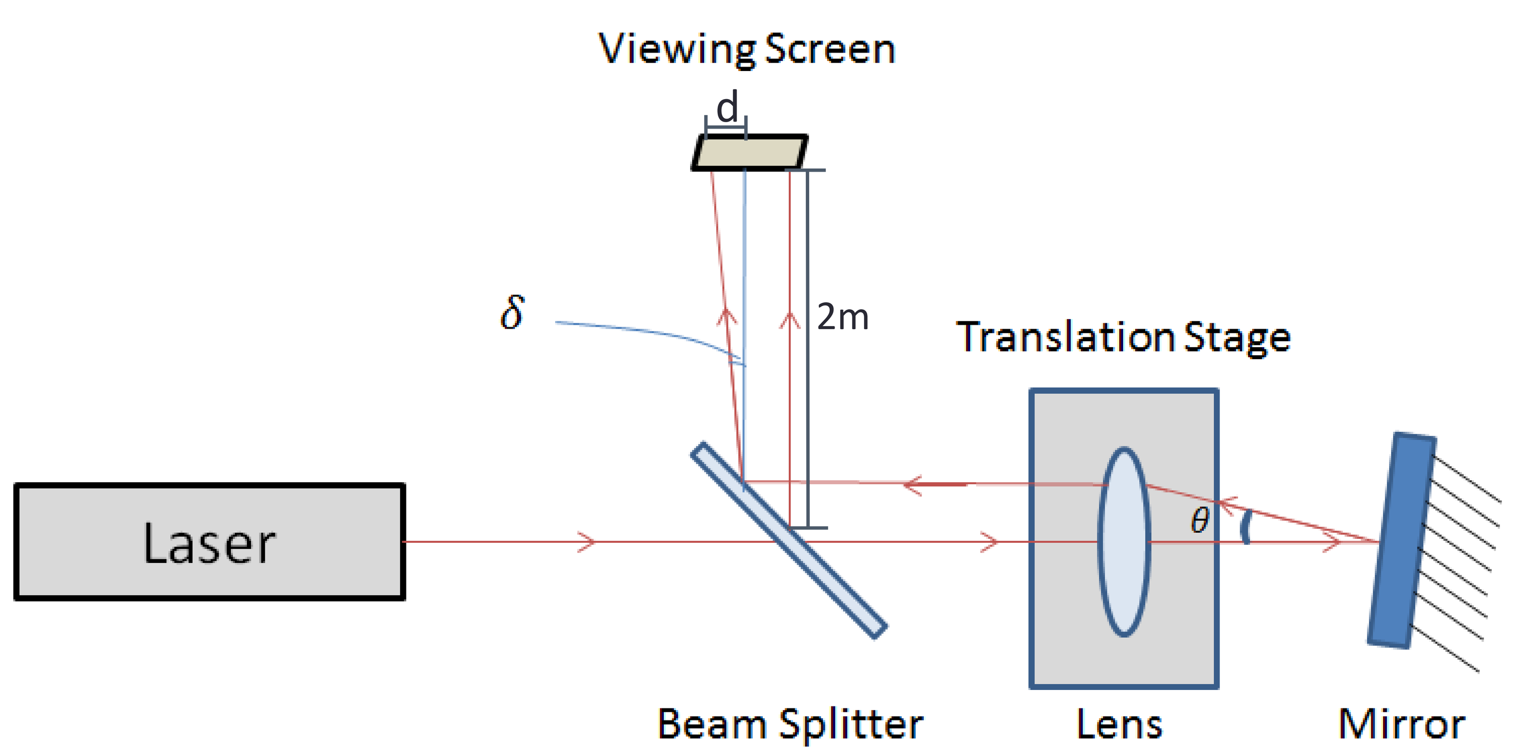
The cat's eye retroreflector has a converging lens and a mirror at its focal point. The light that reflects off of the mirror travels back through the lens again, anti-parallel to its entry path, regardless of small mirror alignment errors.

A retroreflector added to an extended cavity laser partially compensates acoustic noise and misalignments without affecting the laser's output. There are multiple retroreflector setups, however the cat's eye is preferred because its beam displacement is less than that of a more common cube corner retroreflector.

.

OUR SETUP

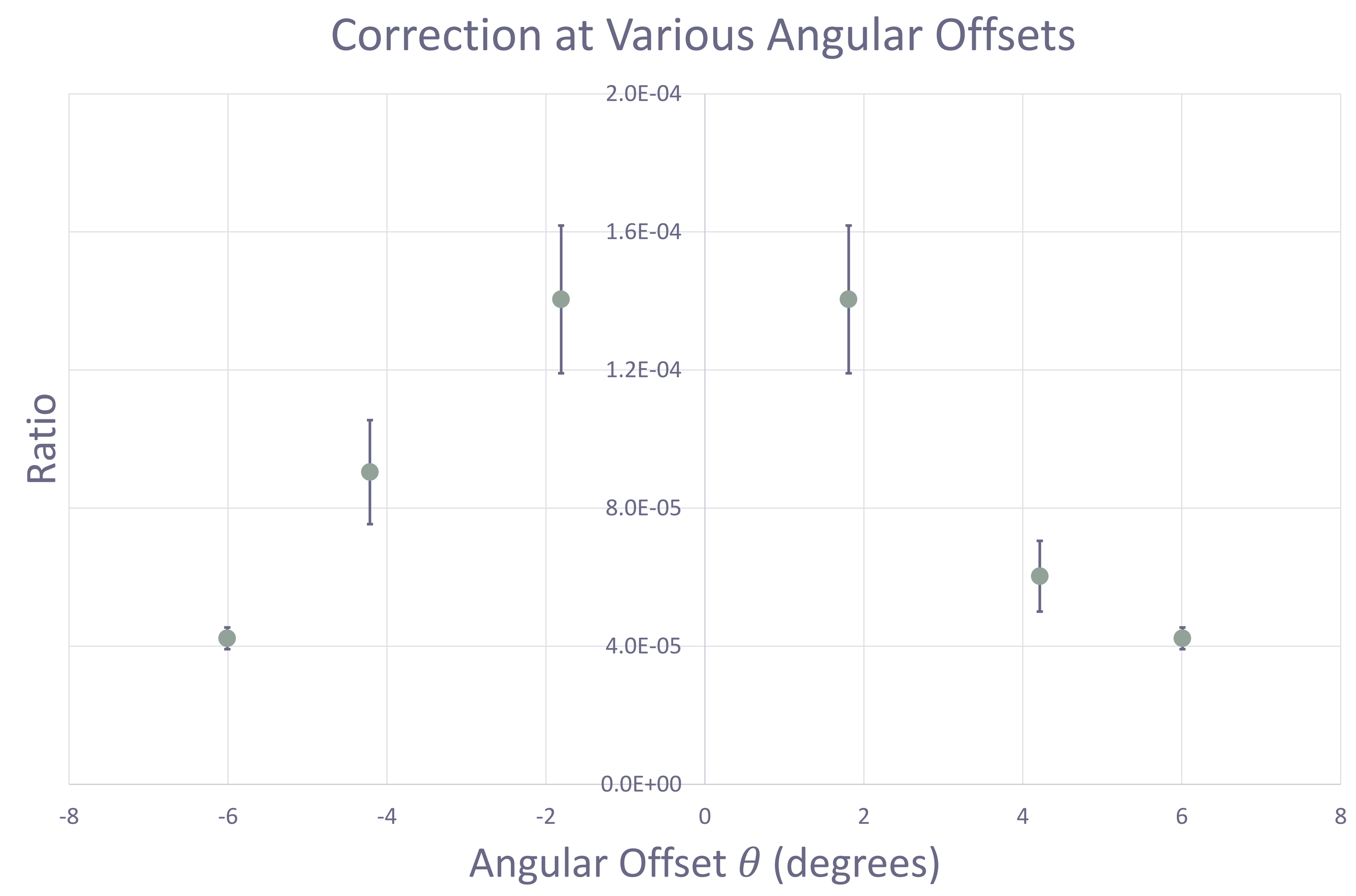
To observe and analyze the misalignment sensitivity of our cat's eye, we used a beam splitter, a plane mirror, and converging lenses as shown below. Thus we could measure the reflection angle of the misaligned mirror and any angular change in the retroreflected beam, and thereby the angular limits of correction.



Light from a HeNe laser is split into beams that travel to the viewing screen and to the spherical lens. A plane mirror, near the focal point of the lens, reflects the light at the angle θ. Thus the beam acquires a slight displacement before it is reflected by the beam splitter to the viewing screen. The lens is mounted on a micrometer translation stage.

θ and δ were measured using the geometries of the setup. To achieve high angular precision, long path lengths were used. The angular correction ratio is defined to be δ/θ.

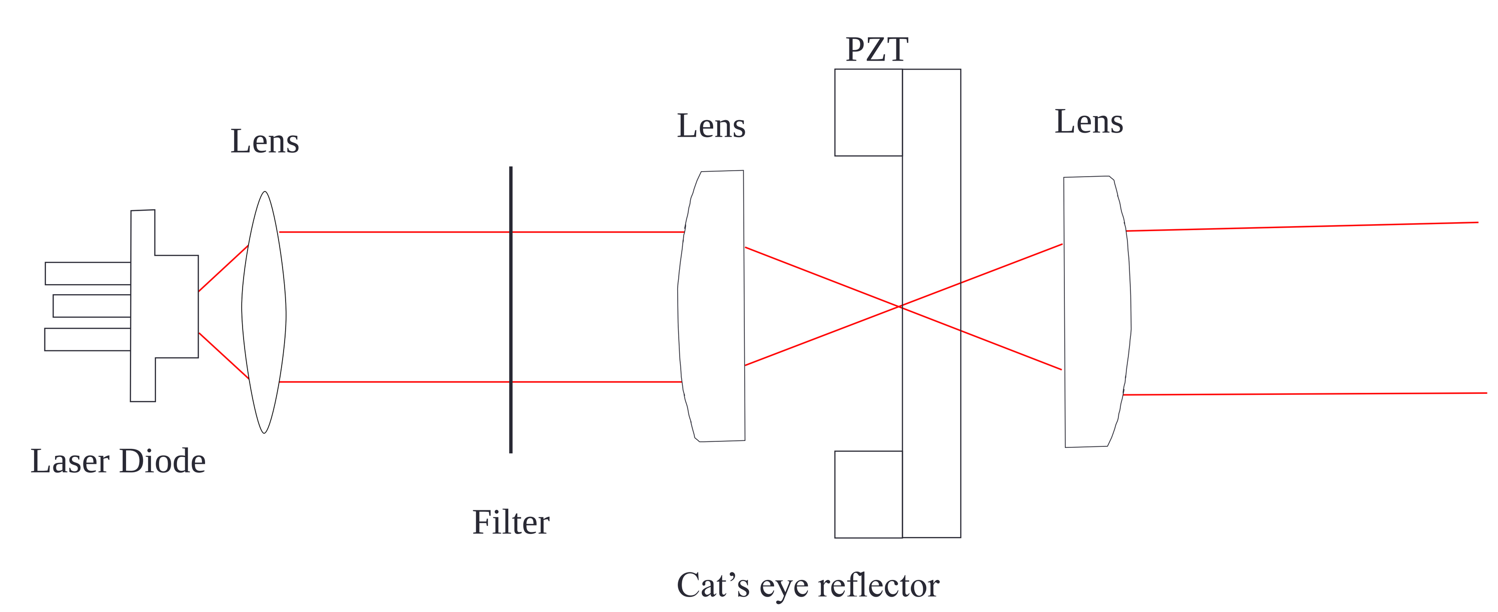
RESULTS (I)



We measured both the deflection angle of the mirror and the angle of the light coming back out of the lens. We used the ratio of these two angles as a measure of the cavity's correcting quality. We measured ratios ranging from 1/20 to 1/600 when moving the lens up to 5 mm away from the focal plane in both directions. We observed that the correction is antisymmetric around the focal point of the lens

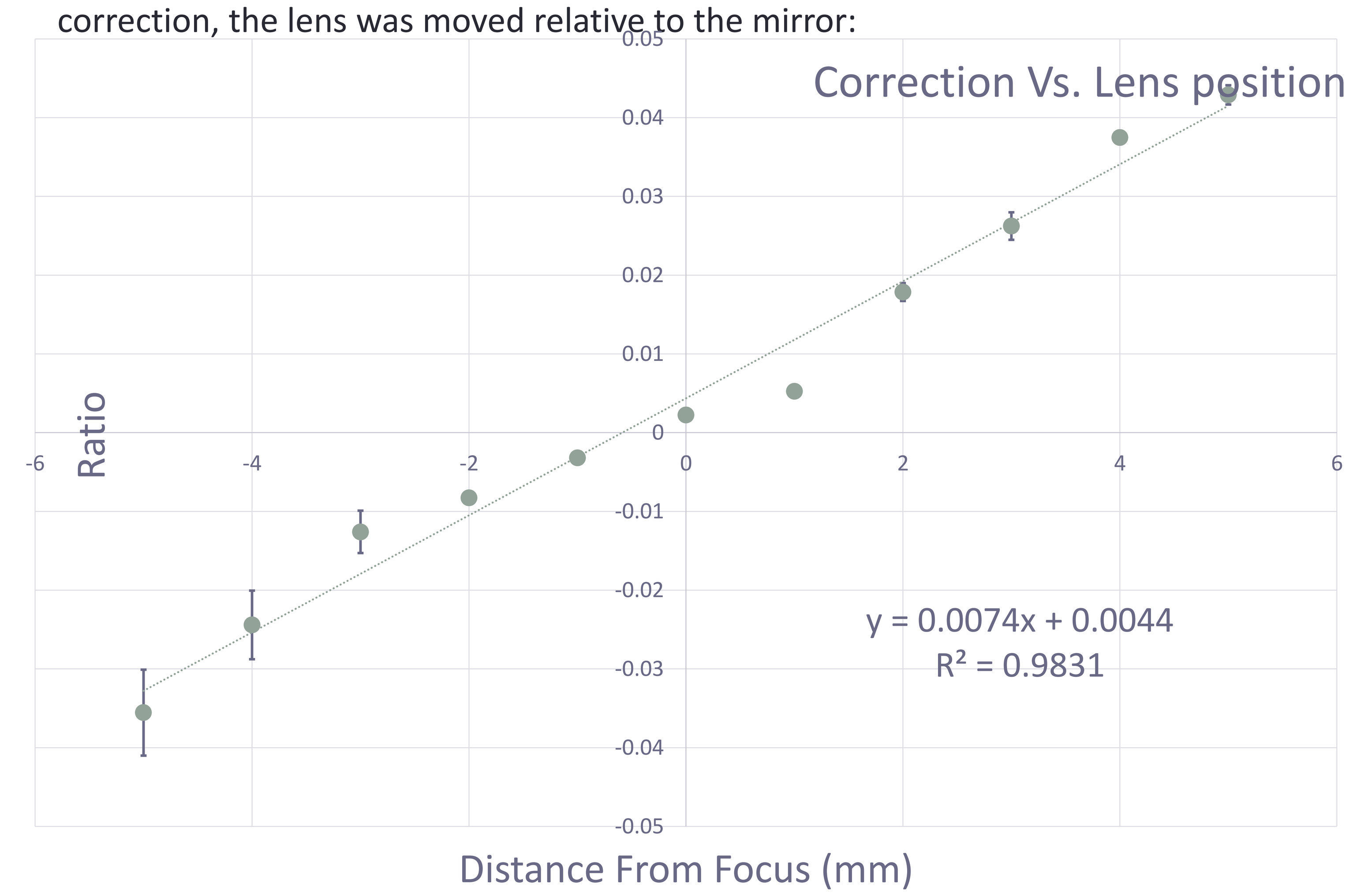
In a perfect lens, the effect of the lens should be independent of where the laser passes through. In comparing θ and δ, there is no relationship between the misalignment of the mirror and δ. The ratio does change because θ is changing as δ remains constant. Thus the larger θ is, the smaller the ratio grows.

COMMERCIAL DESIGN



RESULTS (II)

To see how well aligned the cat's eye needed to be to provide good angular correction, the lens was moved relative to the mirror:



Since ratio varies with θ, ratios were calculated to be the average ratio from three different angle detunings at each position. The error in each point is given by the standard error of the mean.

In moving the mirror away from the focal point of the lens, the ability to correct for angular misalignments decreases linearly. Additionally, in moving through the focus, the angle δ changes sign. These properties are expected from the curved lens formula.

For a 9.5cm focal length lens, we found that the correction ratio changes by $7.4*10^{3}$±$0.7*10^{-3}$ every millimeter. From this fit, the true focal point was determined to be -0.59± 0.32mm away from our measured point. Since this is a spherical lens there is no true focal point but this method could be used as an additional way to find f.

REFERENCES & ACKNOWLEDGEMENTS

[1] X. Baillard, A. Gauguet, S. Bize, P. Lemonde, P. Laurent, A. Clairon, P. Rosenbusch, Opt. Commun. **266**, 609 (2006)

[2] Cateye External Cavity Diode Laser, Moglabs, Version 1.01 (2014)

We would like to thank Harold Metcalf and Marty Cohen for their suggestions and careful editing as well as Brian Arnold for his assistance in the lab.

Supported by ONR