Worried about misalignment? A Novel Locking Clamp for Commercial Kinematic Optical Mounts

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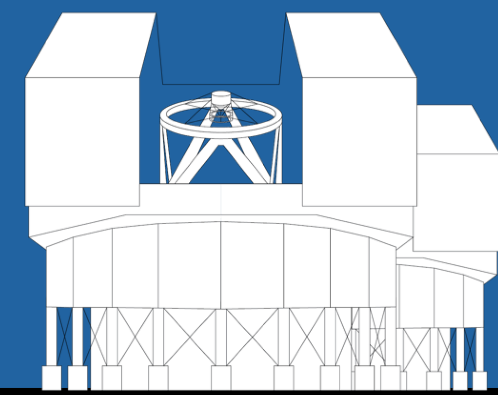


Science Goals of MagAO-X

- Is there life on other planets?
  - We can answer this question if we can image planets around other nearby stars. → Direct Detection Technique
  - The spectra of the planets can be used to look for biomarkers on these other worlds.
- To do this we need a large telescope.
  - MagAO-X will be implemented on the 6.5 m Magellan Telescope in Chile.
- Problem: A complex high-contrast coronagraph is required with a complex relay of 8 2" OAPs.
  - A total of 22 reflecting optics are exposed to vibrations and temperature changes (0-20˚C) → How can we keep the optics aligned to less than 100 microns per 20 degree change in temp?

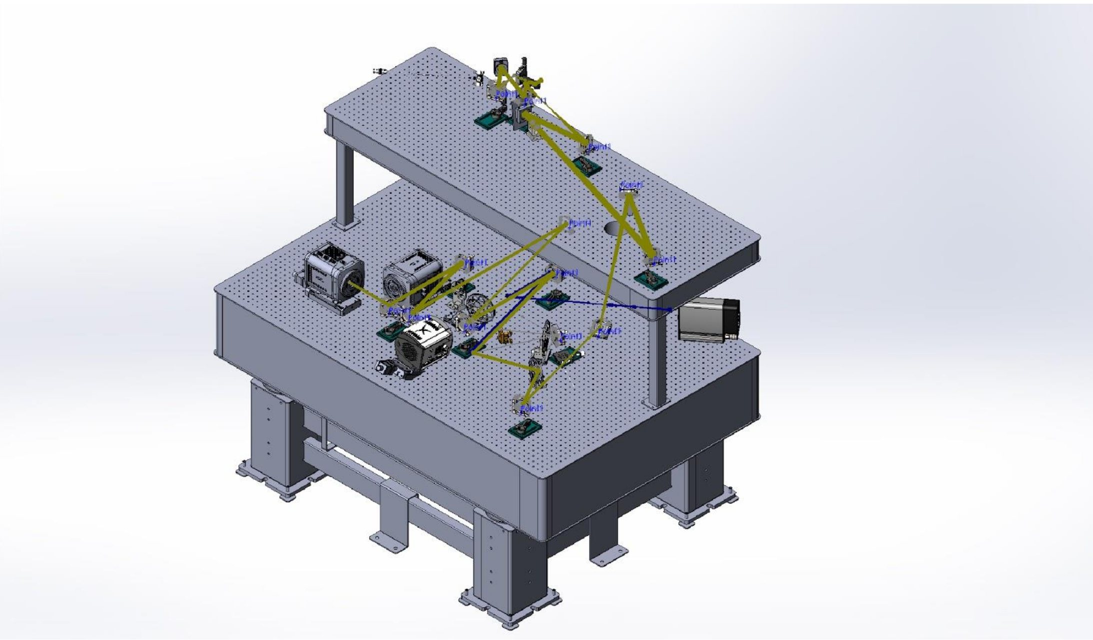


Figure 1. A pictorial representation of the MagAO-X Light Path

Motivation → Solution

- Environment is non-isothermal → Optical misalignment
- No commercial 2" mount w/ zero drift with temperature
- No commercial 2" non-spring loaded kinematic mount – springs vibrate too much to meet spec.
- Need to develop new super stable (5μrad/C) locking clamp prototype
- **Solution:** The locking clamp is comprised of a modified kinematic optical mount, split so the half of the mount that contains the tip/tilt linear actuators is what remains. The clamp is mounted so the linear actuators are set to be exactly aligned with the center of each pad on the mount holding the mirror.

Methods

Method #1

We placed 2" flat mirrors opposite each other in kinematic optical mounts. A laser was reflected 4 times between the mirror, creating a beam path of 24.703m. We taped a piece of paper to a vertical flat surface next to the left mirror to project the final airy pattern. In order to vary room temperature I would turn the AC in the room on and off and measure the movement of the airy pattern as the temp gradually changed.

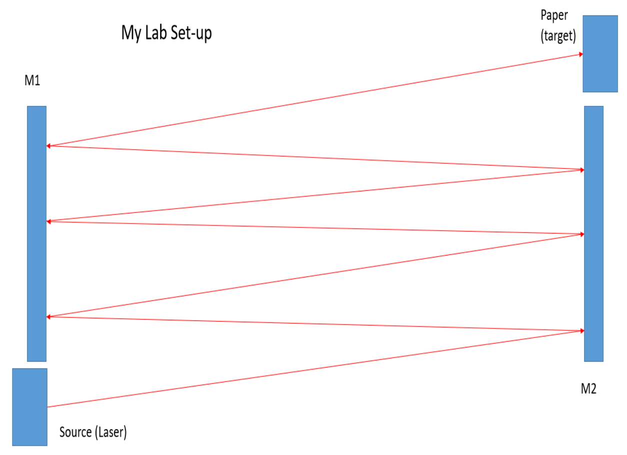
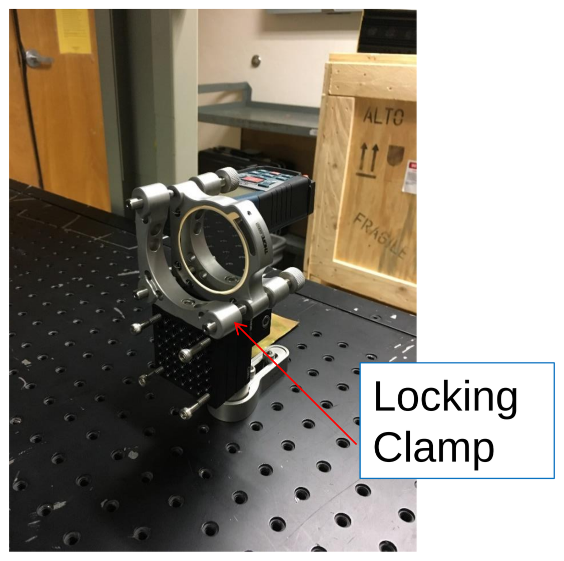
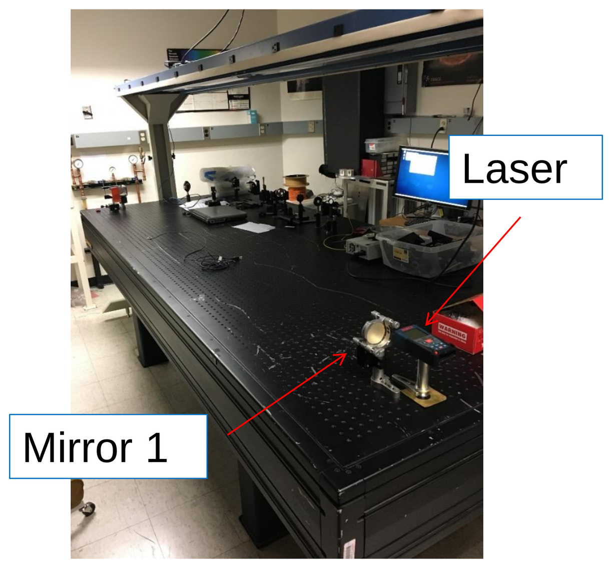


Figure 2. A schematic of the initial lab layout





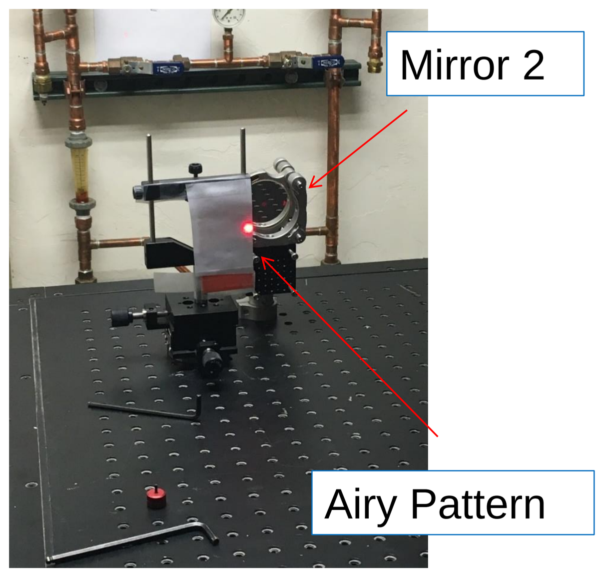
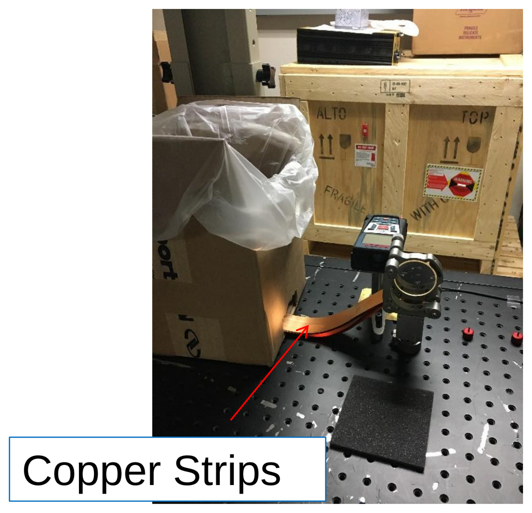


Figure 3. Photos of initial lab set-up

Method #2

An aluminum bowl was filled with boiling water and placed into an open cardboard box with a hole on the side. Several copper strips were stacked together to make a 1.375" wide, 0.06" thick strip and were screwed between the post and the kinematic mount holding the 2" mirror and placed under the aluminum bowl. This caused a heat shock on the mount. A piece of graph paper was next to the mirror on the other side of the optical table so the final airy pattern's drift could be tracked against temperature change.



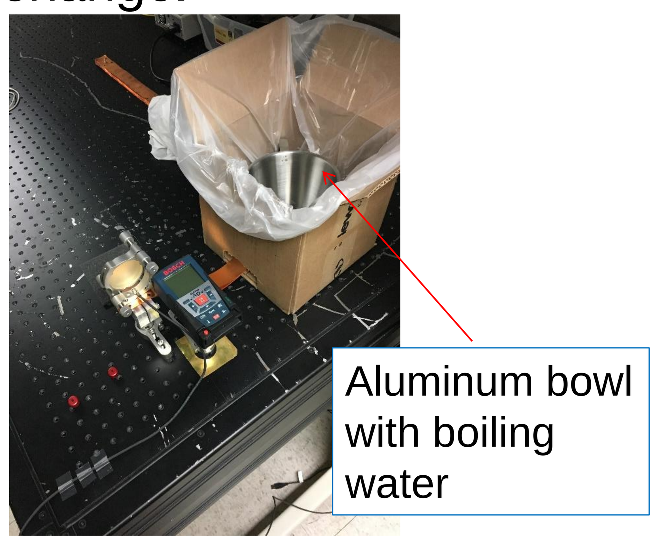


Figure 4. Photos of copper strip "direct thermal shock" (method #2)

Results

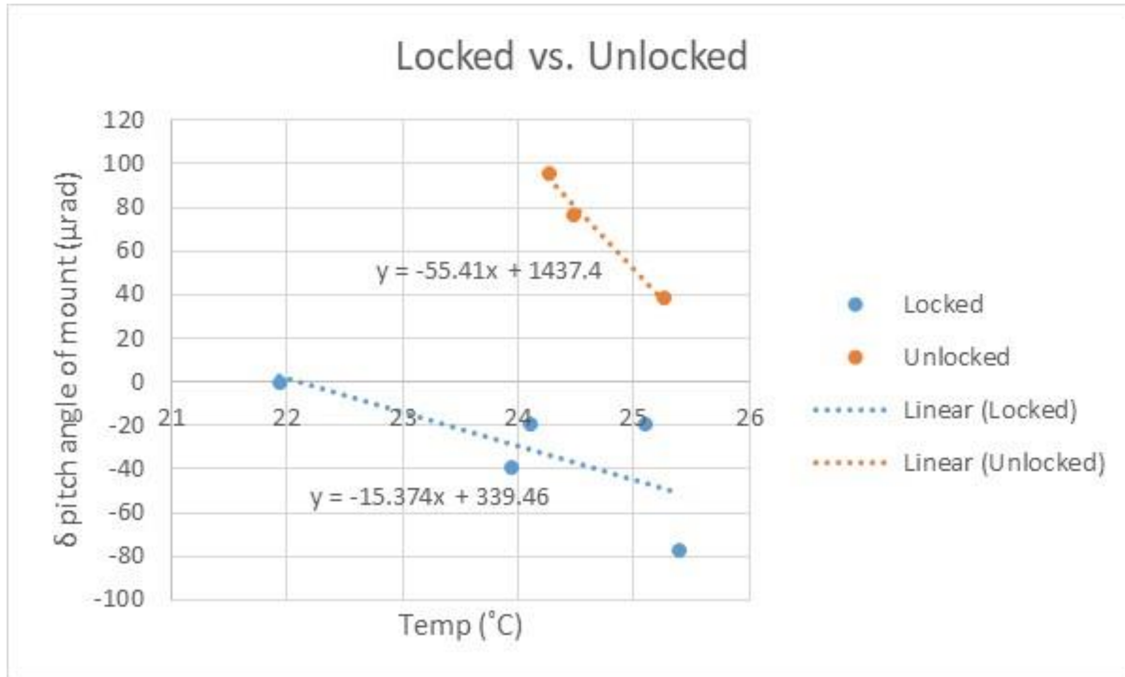


Figure 5. Pitch versus temperature change plot for two clamps in fig 2.

The results indicate that each mount, when unlocked, had approximately 27.7 μrad tilt per degree C whereas once locked (clamps engaged) the mount had approximately 7.6 μrad tilt for every degree C. However, a significant part of this motion is due to the optical table itself warping. So, this is an underestimate of the true stability of the clamps. To fix this we removed the effect of the table with direct thermal shock tests (method #2) -- which just heated the mount. We found 0.3-0.4 μrad/C (locked) compared to 6±1 μrad/C (unlocked). **We conclude that our custom clamping mount has >10 times better thermal stability (0.5-2 μrad/C) than the best stainless steel mounts commercially available today.**

For full details see our Provisional Patent:

A KINEMATIC OPTICAL MOUNT WITH STABILIZING LOCKING CLAMP #62/632,544; filed Feb. 20, 2018; Inventors: Laird Close & Maggie Kautz.

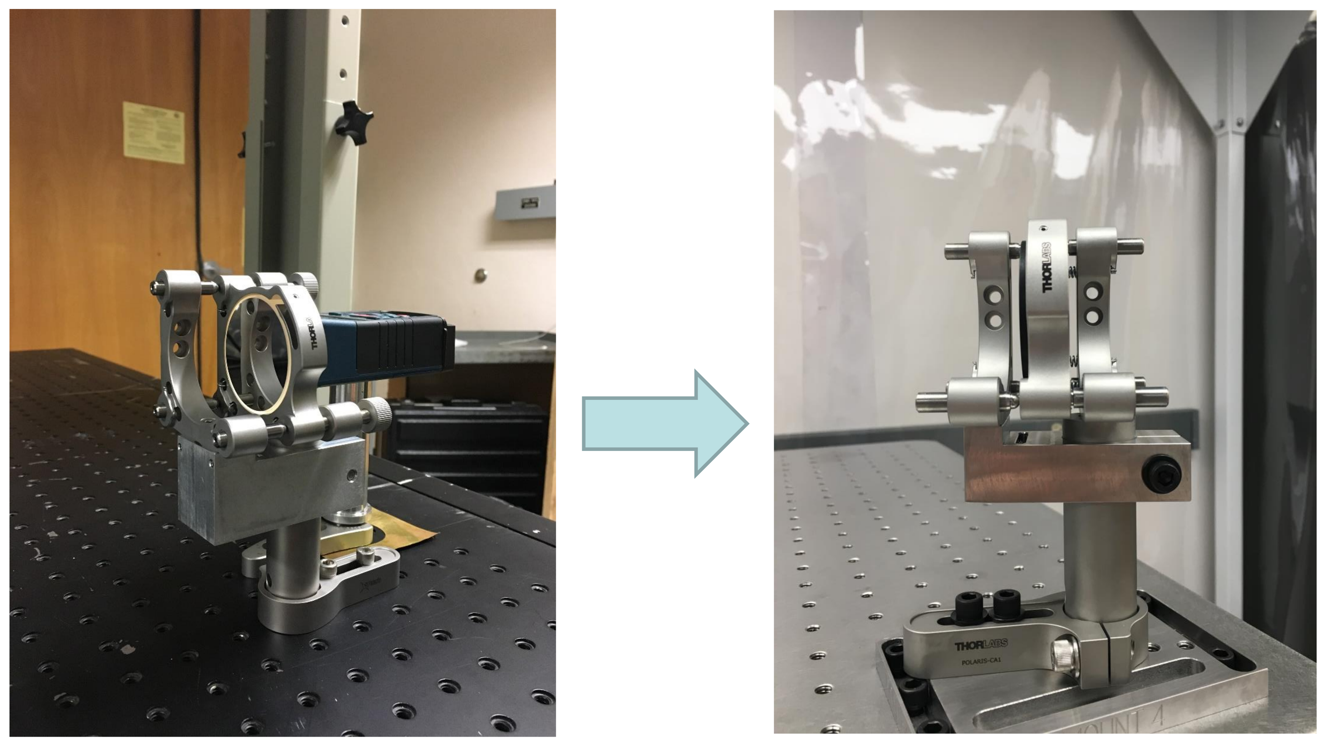


Figure 6. Evolution of the design. We had the prototype support plate manufactured in aluminum but the final clamp (seen here on the MagAO-X bench) is fabricated out of 100% stainless steel to maintain the low CTE and low distortion of the system. It also can provide mounting fiducials and alignment targets for quick and easy OAP alignment. It also provides a safety feature (a Teflon strip) that prevents the escape of an OAP from the mirror cell during shipping.

Acknowledgements

NSF MRI Award Number:1625441
Project Title: OP: MRI: Development of a Visible Wavelength Extreme Adaptive Optics Coronagraphic Imager for the 6.5 meter Magellan Telescope
PI: Jared Males

NSF AAG Award Number:1615408
Project Title: The First Census of Accreting Proto-Planets inside the Gaps of Transitional Dust Disks
PI: Laird Close

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2. Close, L. et al. "The Optomechanical Design of MagAO-X" these SPIE proceedings
3. A KINEMATIC OPTICAL MOUNT WITH STABILIZING LOCKING CLAMP #62/632,544; filed Feb. 20, 2018; Inventors: Laird Close & Maggie Kautz.