Design and Prototyping of Optical Systems for Engineering Applications Experiment 5

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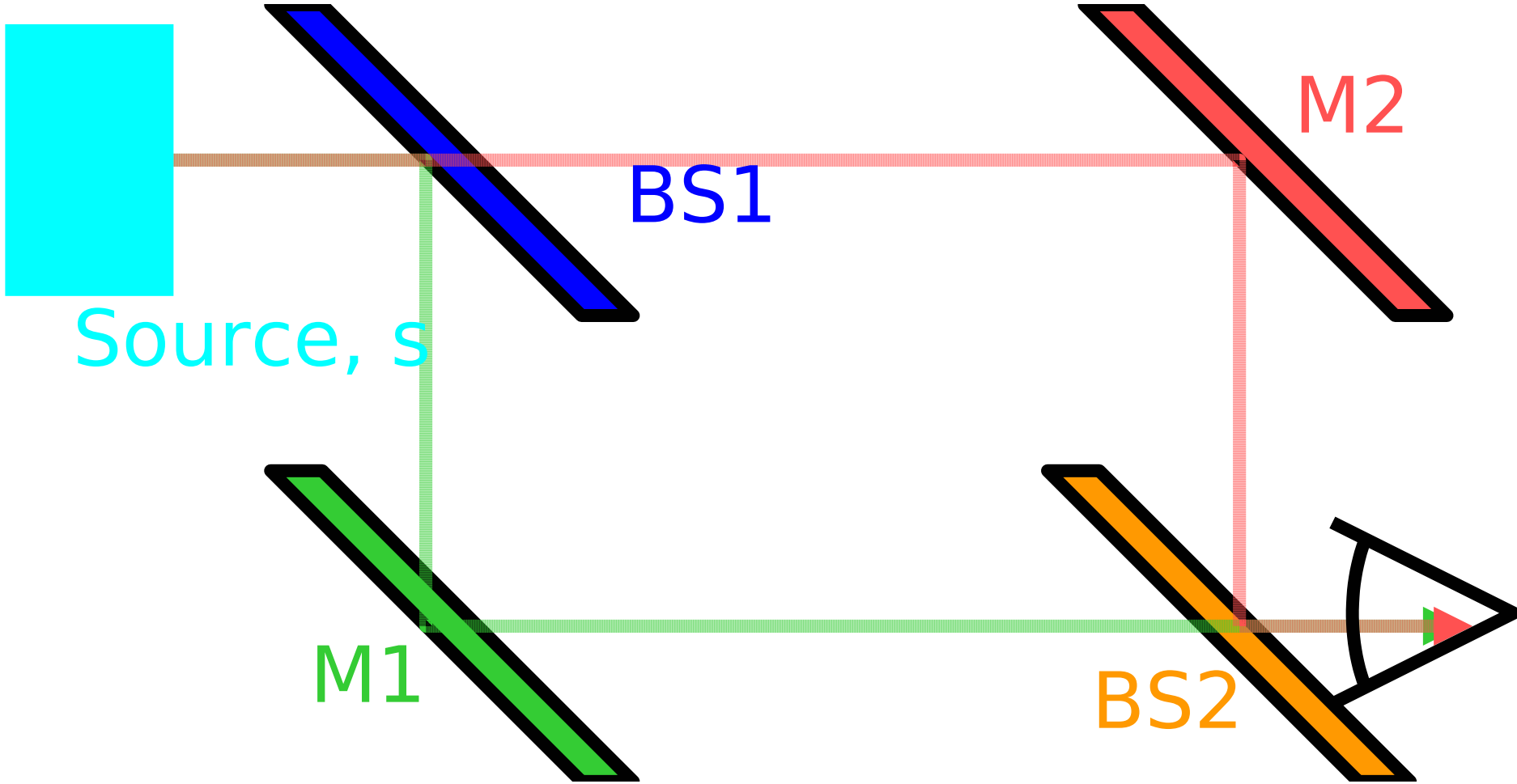
Agenda

- Experiment 4 Results
- Experiment 6 Plans Updated
- Experiment 5 — Interferometer

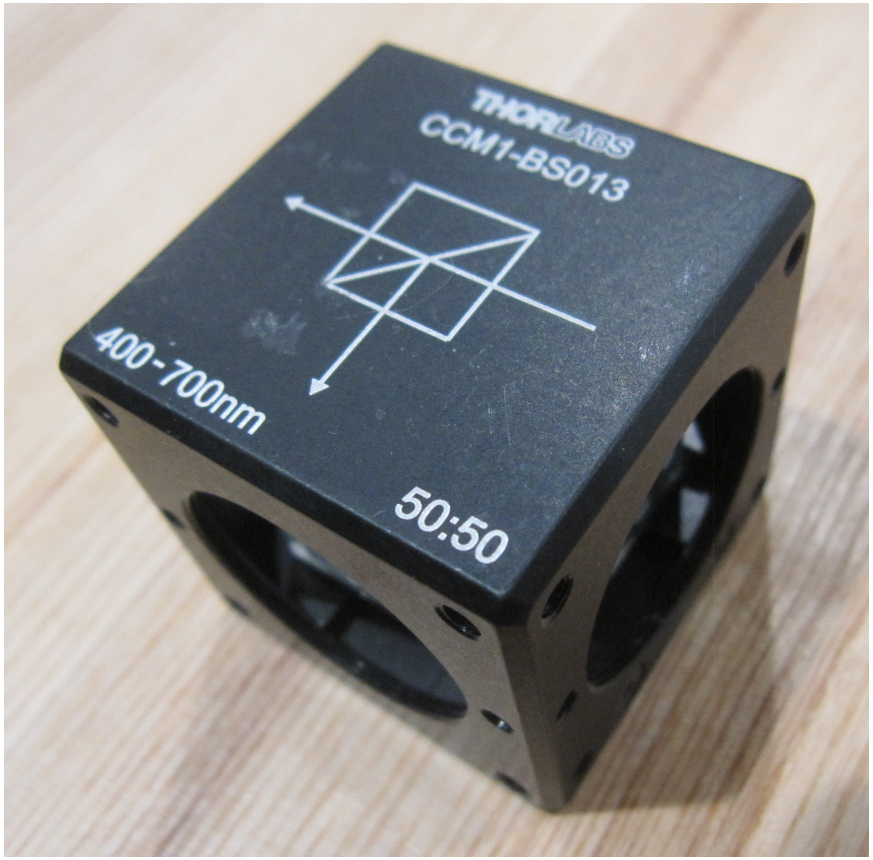
Learning Objectives

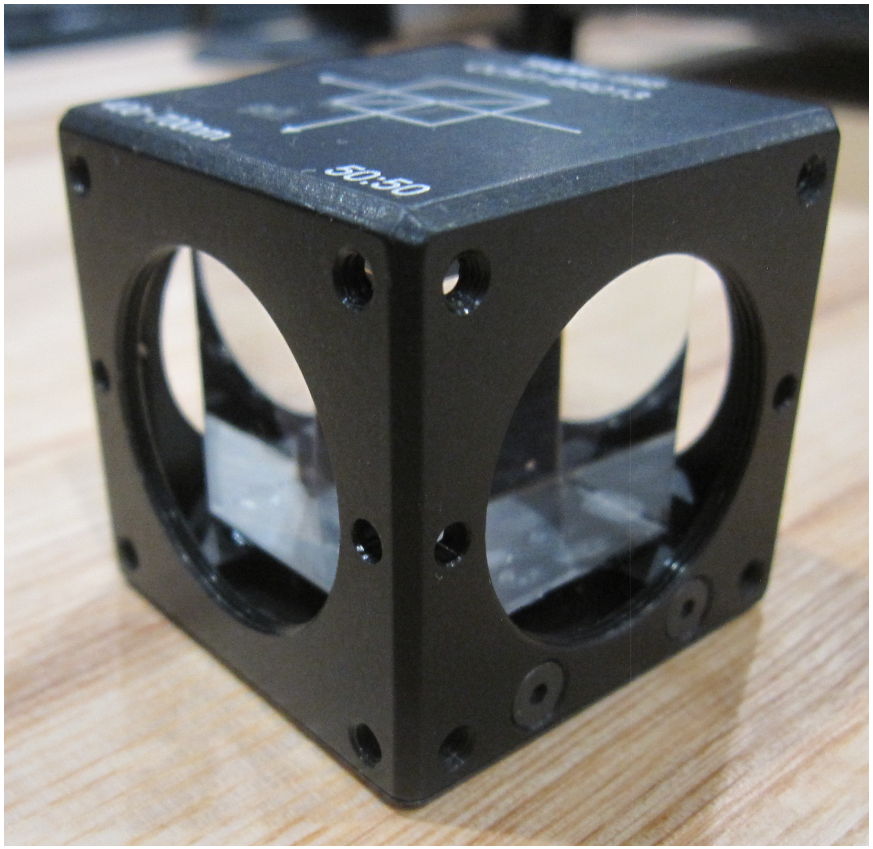
- Interferometry Principles
- Interferometer Design
- Micropositioning Mirrors
- Precision Alignment
- Coherent Light Artifacts
- Phase Measurement

Mach–Zehnder Interferometer

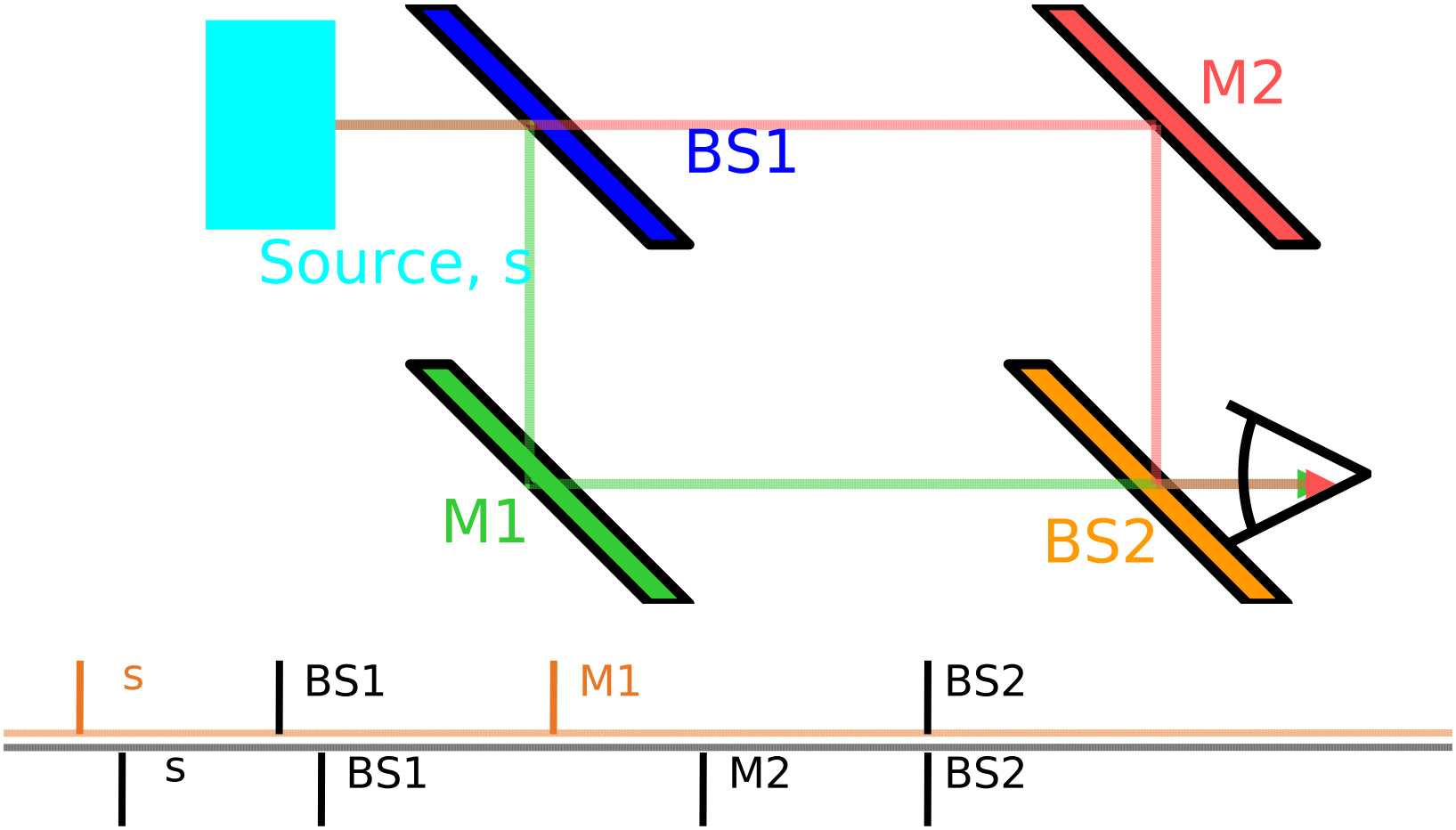


Non–Polarizing Beamsplitter





Optical Path and Geometric Path



Slightly unequal paths lead to fringe pattern

Fringes

$$|E|^2 =$$

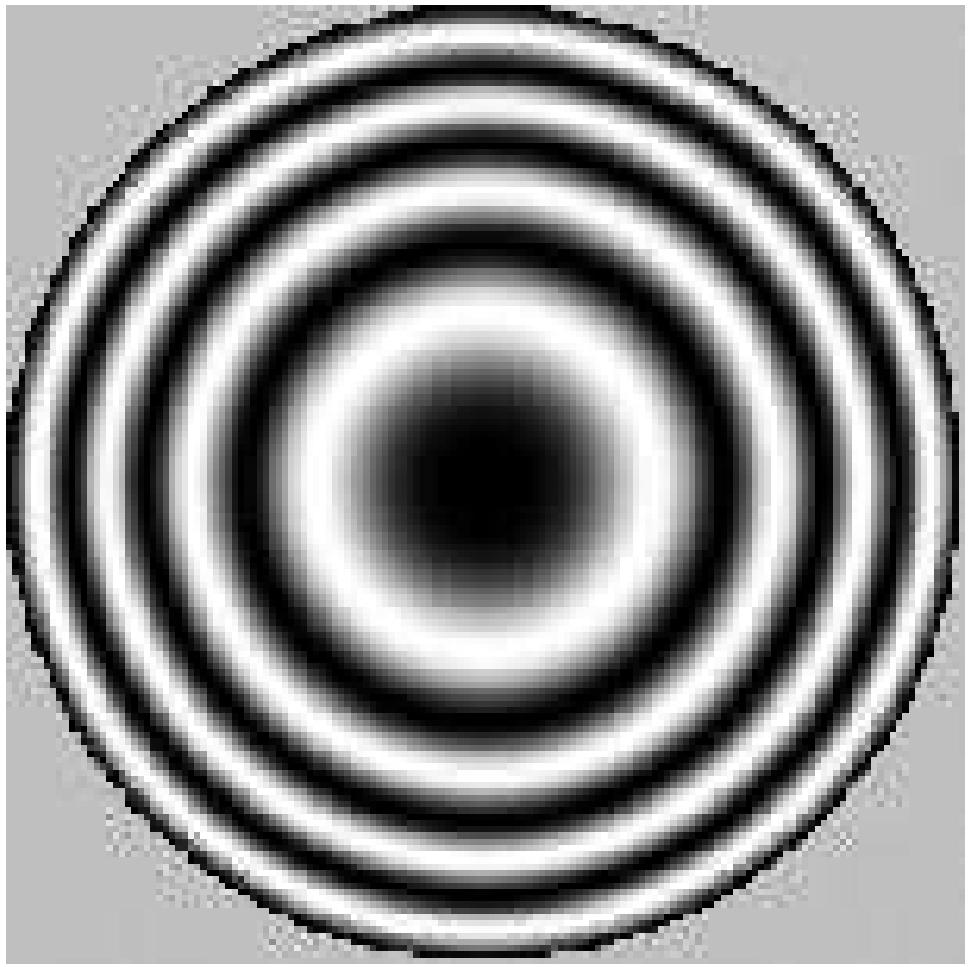
$$(E_1 + E_2)\,(E_1 + E_2)^* =$$

$$(E_1 + E_2)\,(E_1^* + E_2^*) =$$

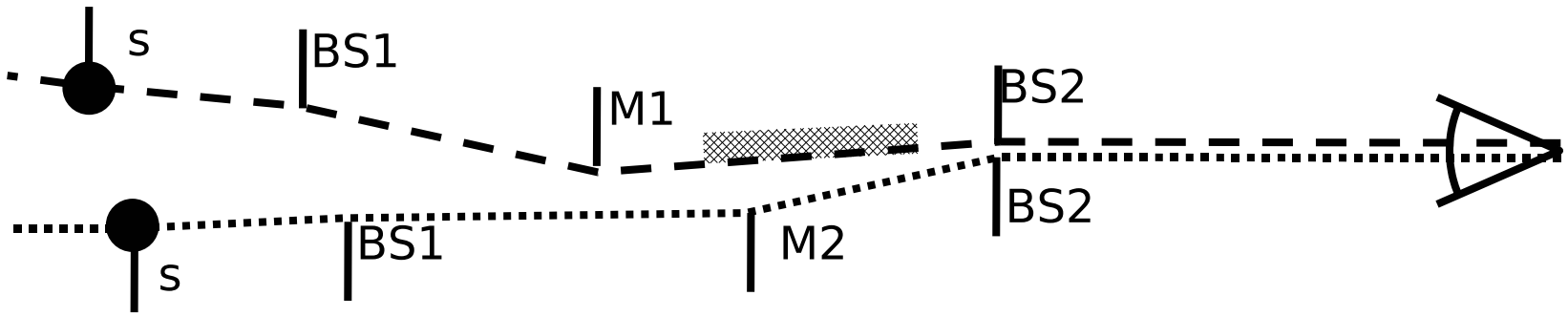
$$|E_1|^2 + |E_2|^2 + E_1 E_2^* + E_1^* E_2 =$$

$$|E_1|^2 + |E_2|^2 +$$

$$2\,|E_1 E_2| \cos \frac{2\pi \Delta s}{\lambda}$$

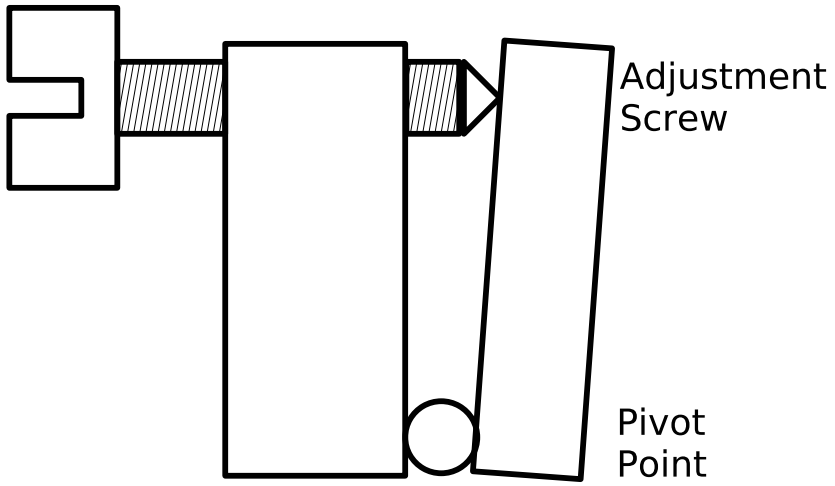


Alignment



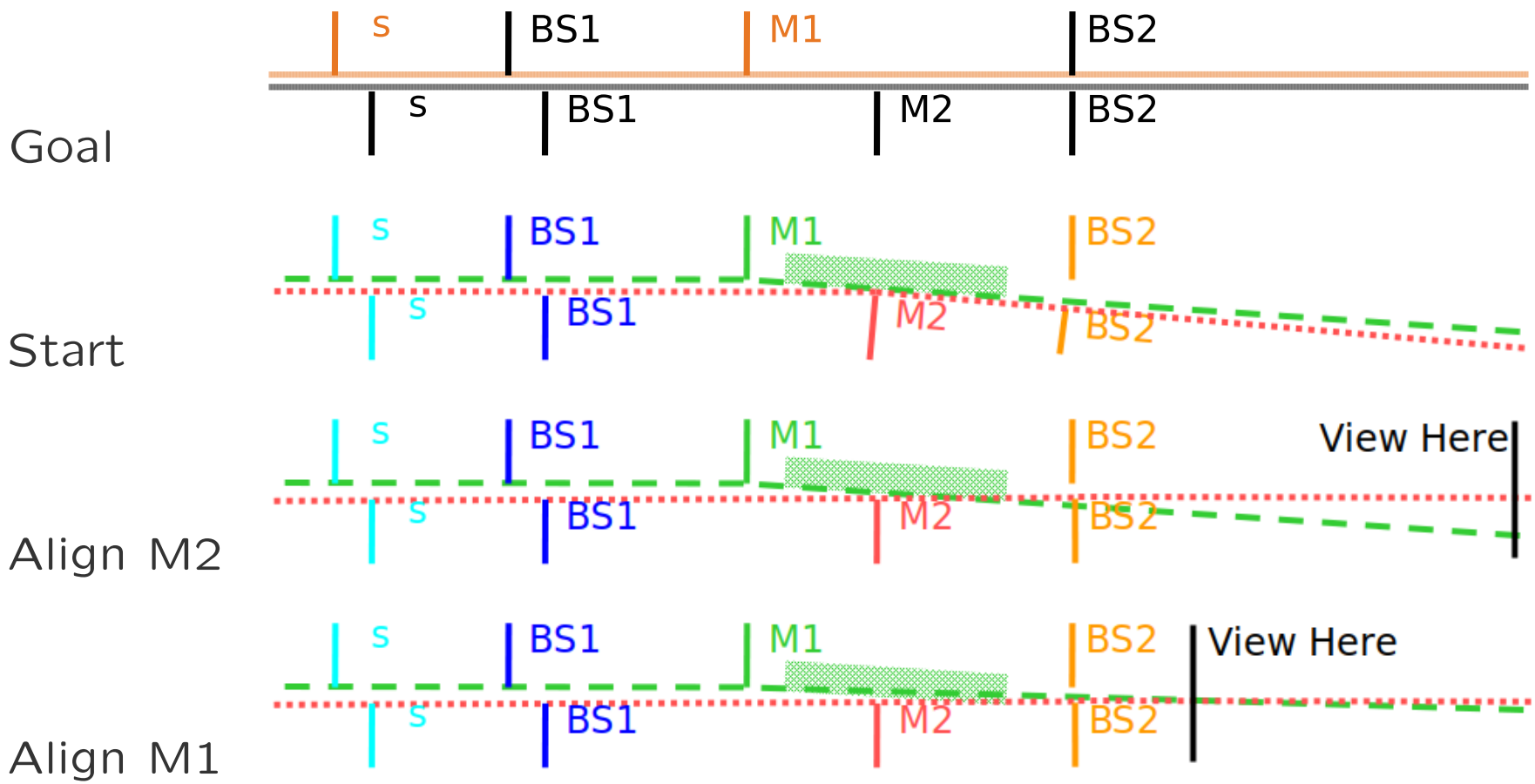
- Avoid Square Design
- Use Iterative Alignment
- Microposition Mirrors

Adjustment of Kinematic Mirror Mount



- Screw Motion 1/40 inch per turn (40 Threads/Inch)
- Angle Measured at Pivot Point
- Wavefront Tilt Twice Mirror Tilt

Iterative Alignment



Iterate: Align M2 Viewing at Far Distance, M1 Near.

Beam Expander

- Enlarge Laser beam to see fringes
- How large?
- Use tubes?

Prelab 5

How many turns of the adjustment screw are required to add one fring across a beam of 1cm diameter, if the adjustment screw is 3cm from the pivot point of the mount and has 40 threads per inch?
Design the layout of your system, including distances and design of the beam expander. Assume that the mirrors will be on tip–tilt mounts that can be adjusted.
Find the index of refraction of air as a function of temperature. Determine how large a temperature change will be observable over an appropriate distance.

Experiment 5

Assemble your system. Leave out the beam expander for the first alignment.
Align so that the two beams are coaxial.
Add the beam expander and adjust for best fringes.
Place a hot object under one of the beam paths and observe fringes.
Mount a camera at the output and collect images of fringe patterns.
Put a glass or plastic transparent slide in one path. See if you can observe imperfections in the slide.
Try an LED as a light source.

Reflection 5

How well did your interferometer work? Did it meet your expectations?
What problems did you have using the camera?
Did the LED source work?
What problems might you have in making quantitative measurements?