Alignment

N. H. Turner & T. A. ten Brummelaar
CHARA, Georgia State University, Atlanta, GA 30303

M.1. INTRODUCTION

The alignment system of the CHARA Array will perform two tasks, maximization of throughput and determination of internal zero-path points. To achieve maximum throughput, the alignment system will be able to send a collimated laser spot backwards through the entire system all the way to each individual telescope. This allows one to center the beam on each element that it encounters in a straightforward manner. To achieve the second objective, the determination of zero-path points, the alignment system will have the flexibility to interfere the return beams from any two telescopes consistent with the current main beam splitter (MBS) layout. It will be able to do this at the laser wavelength as well as with white light, with them both sharing the same reference pinhole.

M.2. COMPONENT DESCRIPTION

The basic components of the system are shown in the master layout of the Array included as a foldout in this report while a hardware tree is given in figure Figure M.1. The "visible light fringe tracker" position of the layout includes a pinhole which is the basis for a shared spatial filter between the white light source and laser. The advantage here is having a stable reference pinhole while being able to switch between sources. Next in the chain after the pinhole is a filter wheel. This will enable a semi-smooth progression of shorter coherence lengths to iterate toward the zero-path point between the two arms of the interferometer. Next, the reference source gets split. The split allows the reference beam to enter either side of the MBS's, which in turn allows the return beam to exit either side to assist in the alignment of *both* fringe tracker spectrographs. The mirrors which steer the reference beams into the MBS's and the mirrors which steer the return beams to the reference quadrant detector (RQD) will each be mounted on their own cart and rail. This makes for 28 mirrors that are either in the beam or out of the beam, which will make the daily alignment more tractable.

After the reference beam enters one side of the MBS's, the light will go in a reverse direction of the starlight until it encounters various selectable sets of either mirror flats or cube-corner retro reflectors. From the perspective of the outgoing reference beams, there will be a set of flats on the main beam combination table, just before the beam leaves the main table (Set A), a set after the IR dichroic beamsplitters but before the beam reducing telescopes (BRT's) (Set B), a set after the BRT's but before the optical path length equalizers (OPLE's) (Set C), a set after the OPLE's but before the telescopes (Set D), and finally, a set of cube-corner retro-reflectors attached to the secondaries of the telescopes, which have sizes matched to the size of the central obscuration (Set E). The Set A and Set B mirrors will be manually serviced by the same set of mirrors on kinematic mounts, where the pitch and yaw adjustors are in the table frame of reference rather than the mirror frame. The Set C and Set D mirrors will also be serviced by the same set of mirrors, only this set is larger to accomodate the larger beams at these points. The kinematic mounts will be of similar design.

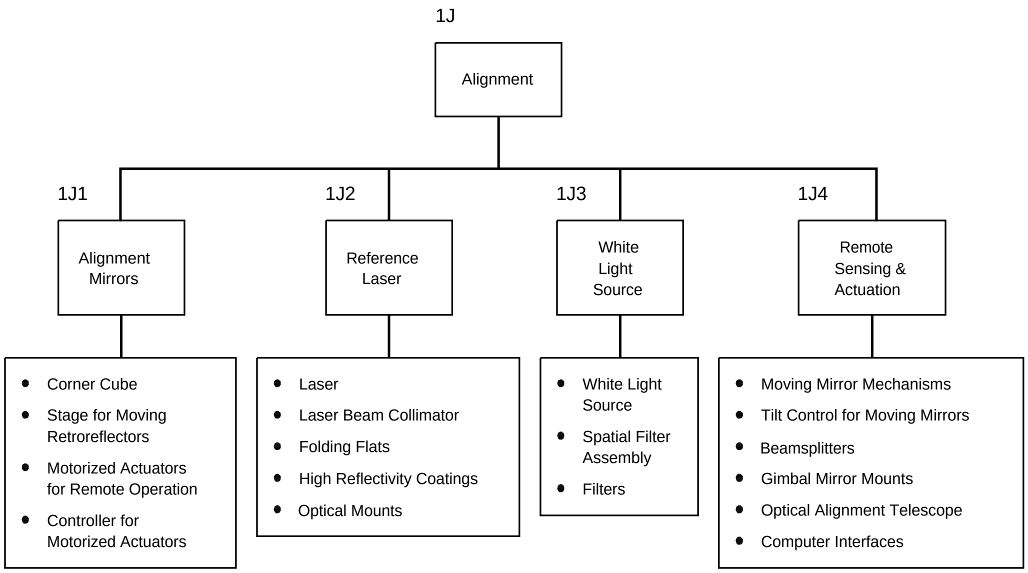

FIGURE M.1. Hardware tree for the alignment subsystem.

The return beams will behave like starlight, with part going to the visual imager, part going to the wavefront tilt corrector, and the rest going to a mirror which in turn sends the beam to an optical telescope as well as the RQD by means of a beam splitter. In addition to the sets of flats, there is a set of shutters between the fringe tracker and Set A which allows the return beams to pass through the fringe tracker one at a time.

M.3. ALIGNMENT OF FRINGE TRACKER

Using mirror Set A, the laser will be used to align the MBS. With use of the shutters and injection points on both sides of the MBS's, all of the dispersive elements and mirrors in the fringe visibility detector can be properly aligned. Letting the two return beams interfere and letting the combined light fall on the RQD allows autocollimation fringes to be detected. Switching to the white light source allows detection of white light autocollimation fringes, and hence, zero-path between the two arms being measured. This will require precise piston adjustments in the Set A and Set B mirrors, achieved by use of a micrometer stage.

M.4. ALIGNMENT OF VISUAL IMAGER

After the fringe tracker is aligned with the RQD, the visual imager will need to be aligned with it as well. This is done by moving the whole input fiber coupling in piston when the RQD has white light autocollimation fringes. Taking data with the system and using the power spectrum algorithms allows the fringes to be recovered when zero-path is achieved. This then ties the visual imager zero-path point to the RQD zero-path point.

M.5. ALIGNMENT OF IR SYSTEM

The Set B mirrors allow the internal alignment of the IR beam combination system with overlap to the visual system. The Set B mirrors will be adjusted to give overlapping return beams at the RQD (i.e. make them like the Set A mirrors, only farther out). Next, dichroic mirrors are inserted to send part of the laser light into the IR system. A second laser will inject light in a reverse direction through the IR fiber. Both beams will encounter a beam splitter in a movable reference jig which consists of the beam splitter, a retro-reflector, a lens, and a CCD camera. The beam coming from the visual table will reflect from the beam splitter into the CCD camera. The beam coming through the IR fiber will reflect off the beam splitter, into the retro-reflector, and back through the beam splitter to the CCD camera. The two beams will form distinct spots on the CCD camera. Adjusting the IR fiber input end such that its spot overlaps the spot from the visual table will align the IR system to the visual system.

M.6. ALIGNMENT OF THE REMAINING PATH

The Set C, Set D, and Set E mirrors allow incremental internal alignment of the interferometer out to the telescopes. This makes for an easier task in bringing each new system into co-alignment with the systems farther down the line. The Set C mirrors are primarily for alignment of the BRT's and therefore require no piston adjustment. The Set D and Set E mirrors/retro-reflectors get their piston adjustment through using the OPLE's. Hence, getting white light autocollimation fringes using the OPLE's gives the zero-path point between the two arms and leads to the internal baseline solutions.

M.7. FREQUENT ALIGNMENT TASKS

From experience with other interferometers, it has become clear that frequent alignment will be necessary. The whole system will have to be autocollimated all the way to the telescopes (using the Set E retro-reflectors) each afternoon prior to observation using the RQD. This will probably be done halfway through the night as well. The amount of time required to perform this task will probably be on the order of an hour or so depending on the skill of the observers, as well as the ability of the interferometer to converge to a consistent alignment.