CHARA Technical Report

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Including the Mt. Wilson 100-inch Telescope in the CHARA Array

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1. INTRODUCTION

In this report, we briefly examine the effect on $U-V$ plane coverage of adding the Mt. Wilson 100-inch telescope as an effective 'sixth' telescope to the CHARA Array.

2. THE MOUNT WILSON SITE WITH THE 100-INCH TELESCOPE

The Mt. Wilson site has been successfully used for interferometry since 1919 and, as discussed in TR 13, has been chosen as the site for the CHARA Array. Figure 1 shows a representative "optimum" array location for five telescopes, similar to that discussed in TR 11. (The final location of the telescopes will depend upon detailed surveying of local terrain for feasibility.) Note that in this Figure the location of the existing (since 1917!) 100-inch (2.54-m) Hooker telescope is denoted by a large square. Fortunately, this telescope is close ($\sim$33 m) to the proposed center of the Array, which has many advantages. First, the 100-in need not have an OPLE, but could serve as a reference point for fringe tracking for the other five telescopes. (Unfortunately, this would not be the case for the 60-in telescope.) Secondly, the propagation distance (either via air or possibly optical fibers) for this beam is small, thus minimizing diffraction or dispersion effects respectively.

Figure 2 shows the $U-V$ plane coverage with an optimum five-telescope Mt. Wilson Y array with and without the 100-inch telescope. Note that the overall coverage is qualitatively better when the 100-inch is included, particularly in the innermost half of the $U-V$ coverage plot. On the weighted coverage scale used in previous Tech Memos, the $U-V$ coverage improves from 0.559 to 0.703, a 26% improvement. (This method essentially counted the number of UV squares that were "covered" on a coarse grid with squares of 35.4 m size. On a four times finer grid of 8.85 m squares, the coverage improved from 0.1447 to 0.2024, a 39.9% improvement.)

Another way of looking at the improvement in $U-V$ coverage, also used in TR 11, was to consider the effect on the reconstructed image of an object, in this case a resolved binary star patterned after the star 29 CMa. The reconstruction algorithm in this case is interpolation in the complex visibility plane. (Obviously, with more points "observed" in the $U-V$ plane,

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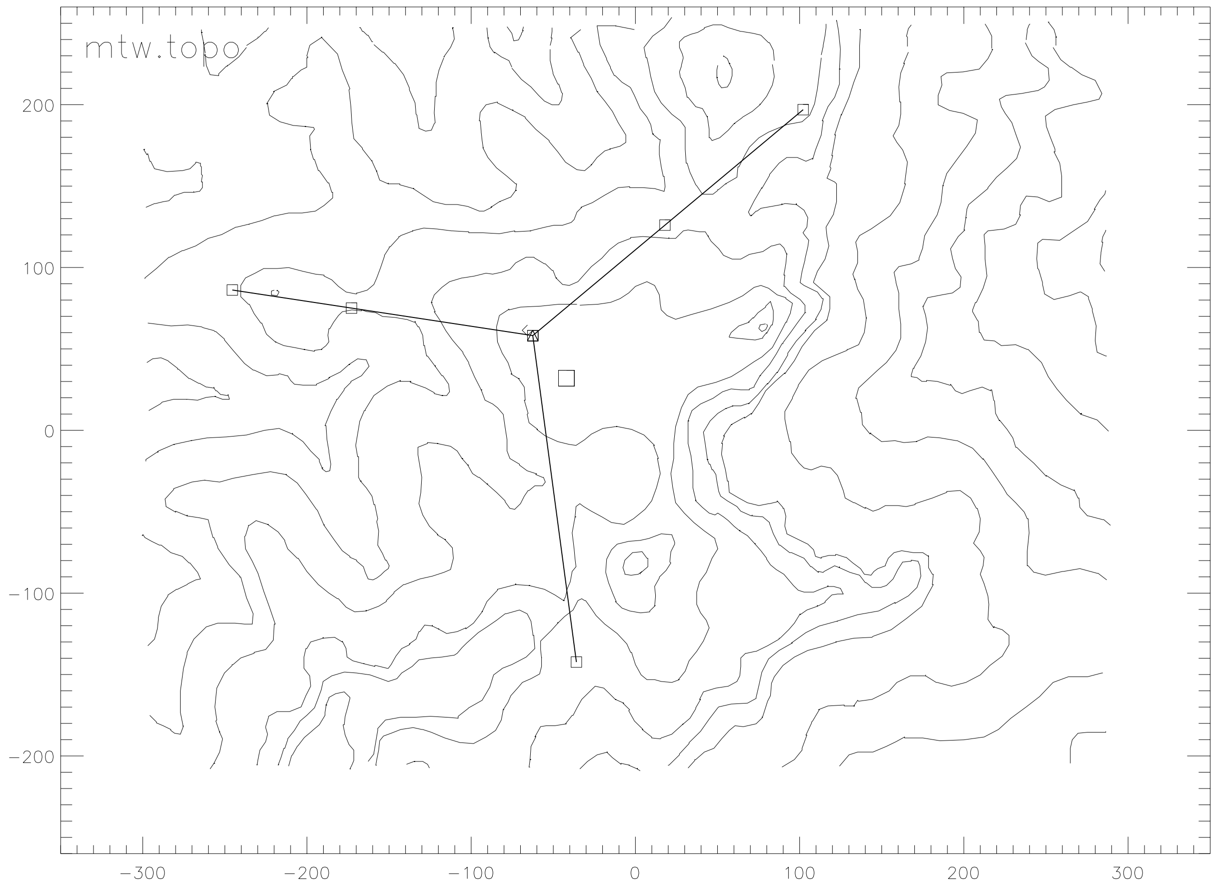

FIGURE 1. Mt. Wilson site with optimum 5-telescope configuration. The Hooker 100-inch telescope is shown as a large open square near the center of the Array.

the image improves.) Figure 3 shows that a qualitative improvement in the recovered image quality occurs with the 100-inch included case.

3. CONCLUSIONS

Addition of the 100-inch Hooker Telescope to the five-telescope CHARA Array could significantly increase the capabilities of the Array. Effective $U - V$ coverage would increase by at least 26%, and as was shown by an example, recoveraged image quality would increase. (The total number of baselines would also increase by 50%, from 10 to 15, and the total number of closure phases would increase by 66.7% from 6 to 10.)

Use of the 100-inch telescope in augmenting the Array would be particularly feasible and useful in the IR. First, observing in the IR would minimize the vibration problems with the telescope (which was of course not designed for this use, but seemed fairly stable during the 1919 interferometry campaign.) Second, errors in the optics would also be minimized. Thirdly, most or all of the pupil could be used under good seeing conditions ($r_0 \approx 100\,\mathrm{cm}$

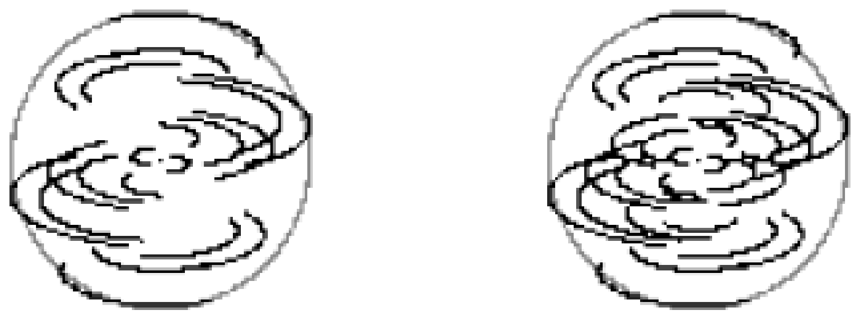

FIGURE 2. Left: UV coverage with optimum 5-telescope configuration. Right: UV coverage including 100-inch Telescope. The outer circle represents a 354 m separation, as in the original CHARA Y.

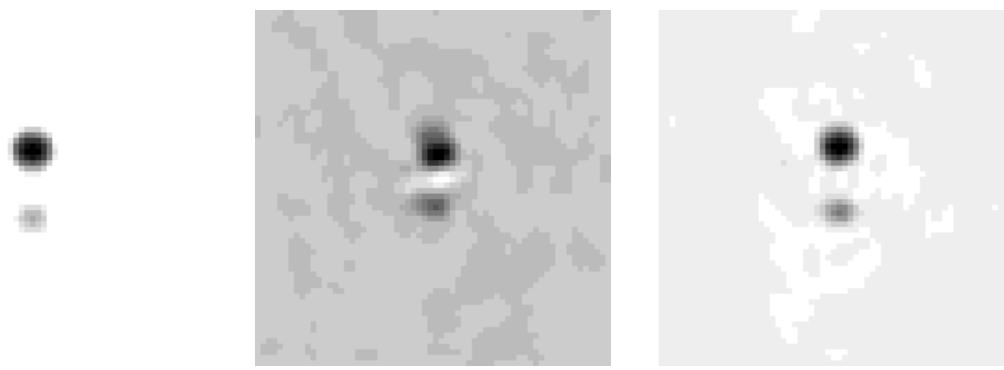

FIGURE 3. Left: Resolved binary image. Center: Image with 5-telescope Array, Right: Image with Array plus 100-inch telescope.

in K). In one application 4-5 subpupils of 106 or 85 cm diameter respectively could be used in combination with the 1 m telescopes. In another application the whole 254 cm aperture could be combined with existing 100 cm apertures to improve the magnitude limit by as much as 1.0 magnitude. Fourth, the location of the 100-inch near the center of the Array means the $U-V$ coverage is improved for shorter baselines, which are more compatible with IR imaging. (In fact we had originally considered a "B" configuration of telescopes to do just this.)

The design of a beam combiner for the 100-inch beam should be considered. Use of the existing coudé beam and additional flat mirrors would be fairly simple conceptually, but the issues of light loss, polarization, and field rotation need to be addressed. Another approach would be to use the Cass or possibly prime focus with a fiber feed to "portage" the light to a beam expander in a convenient location. (This idea was mentioned previously in connection with some proposed CHARA Array telescope designs.) Work on relatively non-dispersive fibers in the K band is progressing at a good rate, so that this could be a viable option in which polarization and field rotation problems could be avoided (light loss would probably be comparable).