CHARA TECHNICAL REPORT

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Alignment Telescopes

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1. OPTICAL ALIGNMENT REQUIREMENTS

The CHARA group foresees regular use of an optical alignment telescope for alignment of the telescope optics (at each re-aluminization of the primary and/or secondaries). As of this writing, the final scheme for alignment of the OPLE (optical delay line) rails has not been determined. An optical alignment telescope is one of several options. An alignment telescope might also to be useful in alignment of the beam compressors, and possibly the mirror chains in the beam delivery systems.

The availability of a television display for the telescope is considered critical, as the alternative is generally to have an additional person staring into the telescope for long periods shouting instructions. Considering the extremely precise nature of the focusing mechanism in alignment telescopes, it appears unwise to attempt to retrofit a camera if there is a commercial alternative.

2. AVAILABLE PRODUCTS

There are not a lot of sources for optical alignment telescopes of laboratory quality. The three manufacturers identified are Davidson Optics, Inc (West Coving, CA), Brunson Instrument Company (Kansas City, MO), and K&E Electro-Optical Products, which is part of Cubic Precision (Teterboro, NJ). The simplest interesting products from these companies are described in the two following tables.

It will be seen that the optical and mechanical characteristics are very similar, as are the basic prices. The products do differ significantly in delivery time. Only the Davidson product is off-the-shelf.

Brunson and K&E telescopes are described as meeting A.I.A. specifications, and these two telescopes also have micrometer adjustable cross hairs for measurements of off-axis angles.

All of the products appear to meet satisfactory optical/mechanical criteria. Only the Davidson product is available with a camera and television display.

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Manufacturer	Model	Price	with CCD Attachment	Availability (weeks)
Brunson	83	\$7575	No	14
K&E	71202	7500	No	24
Davidson	D-275	4235	\$10050	6

Model	Tube Diameter (inches)	Concentricity ($''$)	Range (inches)	Magnification ($\times$)	Resolution ($''$)	Micrometers?
83	2.24955 ± 0.00015	1.	$2 - \infty$	20-30	3.9	Yes
71202	2.24965 ± 0.00015	3.4	$0 - \infty$	4-46		Yes
D-275	2.24966 ± 0.00025	3.	$16 - \infty$	24	5.0	No

3. AN ALTERNATE STRATEGY

A classical alignment telescope of the type described above offers several important features. The most unique is the concentricity of external barrel and optical axis. However, this feature is not likely to be of great importance to CHARA, since in virtually no case will an optical alignment be carried out primarily with respect to a mechanical surface that is readily accesible for alignment telescope installation.

The paramount alignment telescope feature required for CHARA is the maintainance of a consistent optical axis over a large focus range. Telescopes manufactured for theodolites, tansits, and other surveying equipment have a similar requirement. Since the market for such instruments is orders of magnitude larger than for laboratory alignment telescopes, there is more competition and lower prices.

Of the surveying instruments available, an interesting option for an interferometry laboratory is a laser ranging transit. These are now surprisingly inexpensive. The transit-theodolite function can be used for mechanical layout. The laser ranging function can be especially useful for rapid and accurate determination of optical paths[2].

The major disadvantage of the surveying instrument is that it is designed for a very specific mounting interface, which is not immediately compatible with typical laboratory (especially optical table) environments. Use of a theodolite to align telescope optics would also require somewhat more cumbersome interface than would an alignment telescope.

Table 1 summarizes the features of a number of interesting products. These are examples of current products for which product information, sample products, and discount pricing happened to be available in the Atlanta area at this time. It is illustrative only and is not intended to be in any way complete.

The first three entries are for theodolites with electronic digital readout, but without data communication or laser ranging. The last two examples have the latter two features.

Clearly, all of these instruments represent outstanding value. Due to relatively rapid evolution of this technology, used equipment is often available at a fraction of the new price.

[2]At the FLUOR experiment at Kitt Peak National Observatory, it was found that the laser ranging can be used effectively through a relatively complex optical system.

TABLE 1. Selected examples of current model theodolites — comparison of prices and features.

Unit	Pentax ETH-20F	Nikon NE-20S	TOPCON DT-104	Pentax PCS215	Nikon D-50
Manufacturer's Price	$2695	2515	2590	8290	6925
Quoted Price	$2000	1900	2100	5300	
Objective (mm)	45		40	45	36
Magnification (×)	30		26	30	26
FOV (degrees)	1.5		1.5	1.5	1.5
Minimum focus (feet)			2.9	2.8	3.3
Accuracy (arcsec)	20	10	10	5	20
Ranging Accuracy (mm)				3	5.3
Communication	No	No	No	RS232	RS232

However, it is important to verify maintainability of older products.

A shortcoming of all of these instruments is that they are not available with CCD interface to the telescope. However, it was determined that this could be improvised by CHARA staff at relatively low cost. Additional details are available in CHARA Technical Report No. 55.

4. RECOMMENDATION

Based on this review of alignment telescopes and theodolites with and without laser ranging, it was determined that the specifications and price of the the Nikon and Pentax laser ranging units represented an excellent match to CHARA requirements. Similar specifications were used in soliciting bids. The winning bid was for a Pentax PCS 215, at well below the list price.