Stanford University
W.W. Hansen Experimental Physics Laboratory
Gravity Probe B Relativity Mission
Stanford, California 94305-4085

GP-B Telescope
"Determine Reticle Plate Pattern Position"
P0445 Rev -

January 12, 1999

Prepared: _____ Date _____
Ken Bower, Telescope Assembly

Approved: _____ Date _____
Lynn Huff, Responsible Engineer

Approved: _____ Date _____
John Lipa, Telescope Manager

Approved: _____ Date _____
Sasha Buchman, Hardware Manager

Approved: _____ Date _____
Ben Taller, Quality Assurance

DETERMINE RETICLE POSITION

- for SUGP-B P0200(SM) *Bonding the Telescope to the Quartz Block*
- also use *GP-B Telescope Image Divider Assembly (IDA) General Alignment and Bonding Procedures* (SUGP-B P0282) for procedures concerning safety; personnel; work area requirements; fixture cleaning and acceptance; and flight part inspection, handling, storage, and cleaning.

CAUTION:

- The flight telescope used in this operation is heavy, delicate, and somewhat irreplaceable with multiple critical surfaces that can be easily damaged or contaminated by normal handling. Compliance with the above defined safe handling practices is critical.

CAUTION:

- If at any time during this procedure flight hardware is not live monitored, verify that all flight hardware is seismically secured and protected against airborne contamination.

WARNING:

- Some of the solvents, detergents, and/or bonding agents used in this procedure may be flammable, toxic, or reactive. Consult P0282 for information about specific chemicals.
- ESD protection is only required for this operation if compeleted DPA's are installed on the telescope during the operation. As applicable, use P0357.
- This procedure may be completed by a qualified flight part handler (per P0282) and one additional person.
- Redline authority for this procedure is granted to the telescope responsible engineer.

1) Verify cleanliness of all fixturing.
2) Assemble a custom stable frame to support the measuring equipment over the telescope. Secure the frame to the optical table.
3) Assemble the Mounting Plate (OID dwg#620-0069) onto the custom stable frame.
4) Assemble the following hardware (same assembly used in P0373) into a measurement fixture shown in the attached sketch (from bottom to top): 1) a custom platform consisting or five parts to elevate and position the alignment fixturing over the Reticle Plate, 2) a Newport 460A x-y translation stage, 3) a custom adapter plate, 4) a Melles-Griot 07TRT001 rotation stage, 5) a Melles-Griot 07GOH006 Goniometric stage, 6) a Newport 360-90 right angle bracket, and 7) a Newport ULM-TILT Laser Mount.
5) Install the measurement fixturing assembly from step 4 onto the Mounting Plate. Install the DOI model 271 Alignment Scope in the laser mount and tightly secure it with the lock screw and additional Kapton tape as desired.

6) Assemble the following hardware shown in the attached sketch (from bottom to top): 1) a custom rotary stage, 2) a custom tip-tilt stage, 3) a Newport model 401 x-y stage (with actuators), and 4) a custom telescope support plate. Smoothly place a layer of Kapton tape (no overlaps) over most of the top surface of the support plate.
7) Place the telescope fixturing assembly from step 6 centered under the mounting plate and secure it to the optical table.

8) Roughly center the x-y stage, level the tip-tilt stage, and square the rotation stage in the telescope fixturing assembly.
9) Roughly center the x-y stage, level the tip-tilt and goniometric stages, and square the rotation stage in the measurement fixturing assembly.
10) Verify cleanliness of all fixturing.
11) Place the telescope atop the telescope fixturing assembly and roughly center it. **Use great care during this operation to prevent damaging any flight hardware. Two personnel are required for this operation.** Secure to the support plate as desired.
12) Mount a dial indicator (Brown & Sharp Bestest) onto a post and magnetic base. Position the base and indicator to measure run-out on the bottom O.D. of the telescope baseplate and secure in place. Do not bring the indicator point into contact at this time to prevent damage to the indicator during adjustments to the telescope's position.
13) Tune the Alignment Scope into autocollimation mode (infinite focus) and apply power to its internal light source.
14) Rotate the telescope (by means of the rotation stage) and monitor the return image of the reticle plate in the alignment scope. Tip and tilt the telescope (by means of the custom tip-tilt stage) until the return image's motion is minimized. The telescope is now normal to the axis of rotation of the rotary stage.
15) Adjust the angle of the Alignment Scope (by means of the laser mount or goniometric stage) such that the return image is coincident with the internal crosshairs. The Alignment Scope is now also normal to the axis of rotation of the rotary stage.
16) Disable power to the Alignment Scope's internal light source. Focus the Alignment Scope onto the reticle plate pattern.
17) Rotate the telescope (by means of the rotation stage) and monitor the center of the reticle pattern through the Alignment Scope. Translate the telescope (by means of the x-y stage beneath it) until the pattern rotates about its own center. The reticle pattern is now concentric with the axis of rotation of the rotary stage.
18) Adjust the position of the Alignment Scope (by means of the x-y stage beneath it) such that the center of the reticle pattern is coincident with the internal crosshairs. The Alignment Scope is now concentric with the axis of rotation of the rotary stage.
19) Repeat steps 13-18 to correct any changes in alignment and estimate the measurement limits of each step:

Alignment Scope angular resolution:_____
(from Alignment Scope readout in step 13)

Maximum Rotary Stage wobble:_____
(from Alignment Scope readout varience in step 14)

Alignment Scope positional resolution:_____
(from Alignmnet Scope readout in step 16)

Maximum Rotary Stage Run-Out:_____
(from Alignment Scope readout varience in step 17)

Dial Indicator resolution:_____
(from dial indicator display)

Eccentricity of telescope baseplate:_____
(from part inspection report)

20) Calculate the error stack-up.

maximum error:_____

rss error:_____

21) Adjust the position of the dial indicator to bring it into solid contact with the O.D. of the bottom of the baseplate. Rotate the telescope (again, by means of the rotary stage) to find the point of greatest displacement of the indicator needle and set the indicator display to read zero at that point. Record the clocking of this point with respect to the telescope.

Direction of greatest displacement:_____

22) Rotate the telescope and record the dial indicator readings at eight equally spaced locations.

0° (-X, opposite ChB):_____

45° (-X, +Y):_____

90° (+Y, ChA):_____

135° (+X, +Y):_____

180° (+X, ChB):_____

225° (+X, -Y):_____

270° (-Y, opposite ChA):_____

315° (-X, -Y):_____

23) Record the clocking and displacement value of the point of least displacement.

Direction of least displacement:_____

Value of least displacement:_____

24) The direction of eccentricity of the reticle pattern with respect to the telescope baseplate will be the direction of least displacement. The magnitude of the eccentricity of the reticle pattern with respect to the telescope baseplate will be one-half the difference of the values of the greatest and least displacements. Use care to prevent sign errors.

Direction of reticle pattern eccentricity:_____

magnitude of reticle pattern eccentricity:_____

25) Translate the values from step 24 and error stack from step 20 into the X and Y coordinate system of the telescope:

X position of the reticle pattern:_____

Y position of the reticle pattern:_____

26) Evaluate the date taken in step 22 to ensure that all data is consistent with the values recorded in step 25. If desired, the telescope responsible engineer may direct an alternate method for calculating the reticle pattern position. If so, attach an explanation for the reason and methods used.

X position of the reticle pattern:_____

Y position of the reticle pattern:_____

27) Seismically secure the telescope.

Completed by:_____ date:_____

R.E. Approval:_____ date:_____

Q.A. Approval:_____ date:_____

Attachments: SUGP-B dwg#'s 25446, 25091; OID dwg# 620-0069; 2 Assembly Sketches