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GRAVITY PROBE B, RELATIVITY GYROSCOPE EXPERIMENT
STANFORD, CALIFORNIA 94305-4085

MEASUREMENT OF GYRO ALIGNMENT RELATIVE TO THE QUARTZ BLOCK

GP-B SCIENCE MISSION PROCEDURE

5 August, 1998

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PREPARED _____
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APPROVED _____
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1 SCOPE

This document provides the procedure for measuring the alignment of the four science gyroscopes relative to the Quartz Block. The measurements taken reflect parallelism between the Quartz Block polished surfaces and the gyro housing surfaces. The alignment measurements are the two orthogonal tilt angles between the gyro housing surface (on the spacer side) and its polished reference surface on the Quartz Block. This procedure assumes that the gyros have been integrated into the Quartz Block, as described in P0175(SM), and that the integrated SIA is horizontal in the Roller Mechanism on the Optical Table in the Class 10 Cleanroom. This procedure references P0354 for operating the Comparison Autocollimator, Model D-600, and assumes it has been calibrated.

The following operations are contained in this procedure:

1. Set-up and Rough Alignment
2. Measurement of gyro tilt around the SIA Z-axis
3. Measurement of gyro tilt around an axis which is simultaneously perpendicular to the axis in (2) above and parallel to the polished reference surface on the QB for that particular gyro.

1.1 Acronyms

The following acronyms are used in this document

QB	Quartz Block
QB/T	QB and Telescope Unit, bonded together
RM	Quartz Block Roller Mechanism
QB/T/RM	QB/T Assembly in Roller Mechanism
G1, ..., G4	Gyro in Position 1, etc.
S-side	Spinup (Spacer) side of Gyro Assembly
R-side	Retainer (Caging) side of Gyro Assembly
SIA	Science Instrument Assembly
ITD	Integration and Test Director
QA	Quality Assurance

2 REFERENCES

2.1 Plans and Procedures

P0059	GPB Contamination Control Plan
P0057	Stanford Magnetic Control Plan
P0354	Operation Supplement for Comparison Autocollimator, D-600

3. GENERAL REQUIREMENTS

3.1 Environmental Requirements

This procedure is conducted in the Stanford Class 10 Cleanroom in the HEPL facility.

3.1.1. Cleanliness

The Class 10 clean room where this integration takes place shall be maintained at the cleanliness levels per GPB Contamination Control Plan (P0059). Certified Class 10 cloth garments shall be worn in the Class 10 clean room.

3.1.2 Particulate Contamination

All parts and tools shall be cleaned at least to the cleanliness levels of the rooms where they are used for assembly or testing. In addition, all flight parts shall be maintained at level 100 cleanliness per GP-B Contamination Control Plan (P0059). Take all necessary precautions to keep tools and handling equipment free of particulate contamination.

To the maximum extent possible, personnel shall keep all parts of their bodies downstream of the QB/T, defined by the direction of HEPA airflow.

3.1.3. Magnetic Contamination

All parts and tools shall be screened per Procedure P0057. Tools to be sprayed with Freon from pressure can (filtered to < 0.2 micron) prior to each use, or when contaminated.

3.1.4. Electrostatic Discharge Control

The particle ionizer shall always be upstream of the quartz block relative to the fan wall, to prevent electrostatic charge buildup on the quartz block.

3.2 Integration and Test Personnel

3.2.1 Integration and Test Director

The Integration and Test Director (ITD) shall be Dr. Doron Bardas. He has overall responsibility for the implementation of this procedure and shall sign off the completed procedure as well as other intermediate sections where designated.

3.2.2 Personnel

All engineers and technicians participating in this procedure shall work under the direction of the ITD who shall determine whether the person is qualified to participate in this procedure. Personnel anticipated to be participating in this procedure are J. Efraín Alcorta, C. Gray, J. Stamets, and D. Bardas.

3.3 Safety

3.3.1 General

Personnel working in the Class 10 Cleanroom must be cognizant of the base of the Precision Manipulator, and take special care to avoid tripping or bumping into it.

Safety Engineering to be notified prior to any major movement of the SIA. (i.e., any movement other than rotations or minor adjustments)

3.3.2 Hardware Safety

Extreme care must be taken to avoid accidentally bumping or scratching the SIA, especially the telescope which protrudes over the side of the optical table. **Extreme care must be taken to avoid touching the polished surfaces of the QB and Telescope.**

3.3.3 Maximum Number of People in Cleanroom

Under normal operating conditions, there shall be no more than 5 people in the Class 10 Cleanroom. This is to avoid violating legal make up air requirements, and to provide an efficient workspace. Exceptions must be for short periods only, and be approved by the test director.

3.4. Quality Assurance

This measurement shall be conducted on a formal basis to approved and released procedures. The QA program office shall be notified of the start of this procedure. A Quality Assurance representative designated by B. Taller shall review any discrepancy noted during this procedure, and approve its disposition. Redlines shall be stamped by the QA rep. The QA representative will nominally be A. Nakashima. Upon completion of this procedure, the QA program engineer, B. Taller or P. Unterreiner, will certify his concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating in the designated place(s) in this document.

3.5. Red-line Authority

Authority to red-line (make minor changes during execution) this procedure is given solely to the ITD. Approval by the Hardware Director shall be required, if in the judgment of the ITD or QA representative, experiment functionality may be affected.

4. REQUIRED EQUIPMENT

The following equipment shall be in the Class 10 cleanroom.

Flight Hardware
SIA Kit, P/N 23170-101

Ground Support Equipment
Oriel Optical Table
Davison Optronics D600 Comparison Autocollimator

D-600 Full Calibration Date _____

Davison Optronics D247 Precision Elevation Instrument Stand
Optically falt mirror to $\lambda/20$ or better, mounted in Mirror Stand
Dolan-Jenner Industries Fiberlite Model 190

5 SET-UP AND ROUGH ALIGNMENT

5.1 Room Setup

Record Start Date and Time _____

5.1.1 Setup the Class 10 room so that the optical table with the Quartz Block end is facing the Observation wall. See Figure 1 below. Personnel are to work downstream of the SIA relative to the HEPA fans to avoid particulate contamination of the SIA.

5.1.2 Clear off anything on the floor which are not used during integration, and put in Class 1000 Room. Clear the area around the Optical Table, to prevent accidental tripping or bumping.

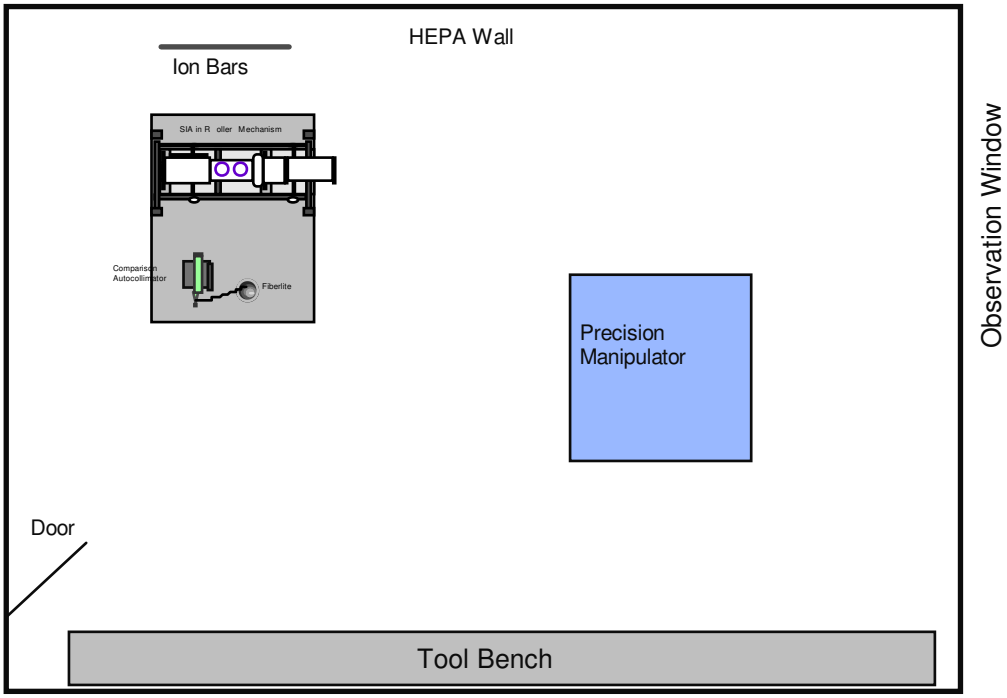

Figure 1. Room Setup For Gyro Alignment Measurement

5.2 Optical Table Setup

5.2.1 Move the QB/T/RM to the back of the Optical Table, so there is room on the table for the Instrument Stand, and Fiberlite.

5.2.2 Place the Instrument Stand on the Optical Table, in front of the QB.

5.2.3 Place the Autocollimator on the Stand, pointing at the QB. See Figures 1 and 2.

5.2.4 Place the λ/20 flat mirror on its optical stand between the Comparison Autocollimator and the QB/T/RM. Perform the "zero check" as described in P0354, Section 1.3.2. Determine offsets to be used, if necssary,_____

5.2.5 Rotate the QB/T/RM so that the bore of the Gyro whose tilts are to be measured is parallel to the table, with the gyro spinup half facing the autocollimator.

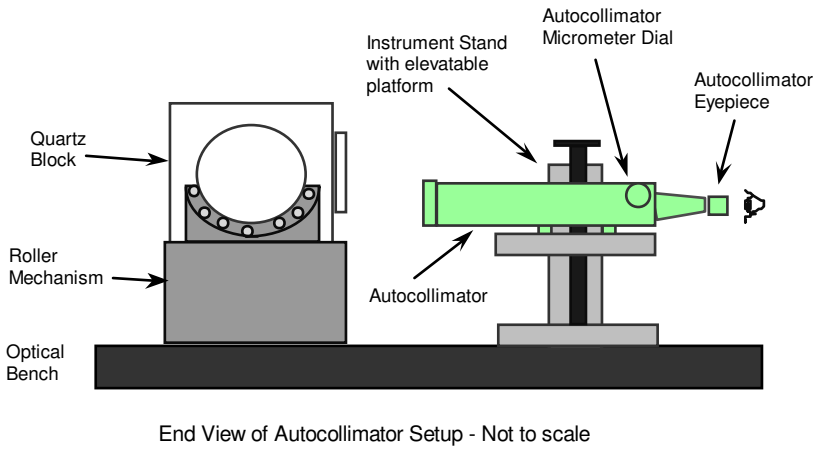

Figure 2. Setup on Optical Table

Note: The Comparison Autocollimator is supported by three ball feet, two aft and one forward. These feet are located on two sides of the D-600 so that tilt angles about two orthogonal axes can be measured. For tilt measurements around a horizontal axis, the micrometer dial is located on the side of the autocollimator, while for tilt measurements around a vertical axis, the micrometer dial is located on the top of the autocollimator.

5.2.6 Connect the Fiberlite Model 190 (illuminator) to the Autocollimator in the slot near the eyepiece. See Figure 3 below.

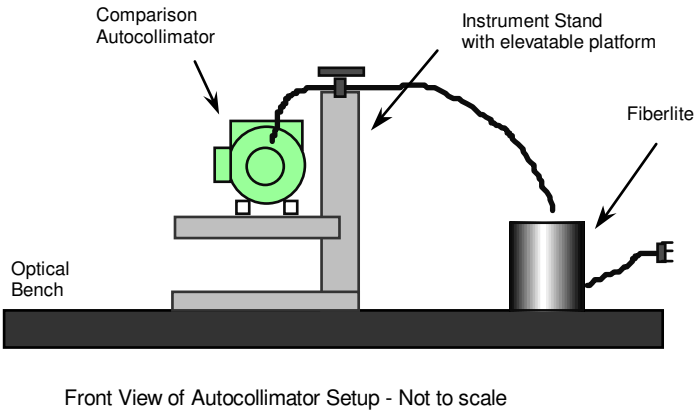

Figure 3. Autocollimator Setup

5.2.7 Adjust the height of the stand so that the Autocollimator boresight is approximately level with the lower half of the gyro bore for gyros 2 and 4, and level with the upper half of the gyro bore for gyros 1 and 3.

NOTE: Figures 4 and 5 shows the setup for gyros 2 & 4. For gyros 1 & 3 the view would be rotated 180 degrees.

6 MEASUREMENT OF TILT AROUND A VERTICAL AXIS

NOTE: SECTIONS 6 and 7 ARE GENERIC EXCEPT FOR ROTATION.

6.1 Masking

Note: To obtain the most accurate results, only flat surfaces in the field of view of the Comparison Autocollimator which are to be measured should be exposed. All other surfaces need to be masked to avoid image confusion.

6.1.1 The Autocollimator should be on the feet such that the micrometer dial is on the side. With the eyepiece removed, fine-adjust the autocollimator height and angle so that a green reflection of the quartz surfaces of the gyro housing and QB polished surface are simultaneously observed. (The QB in its roller mechanism may also have to be adjusted). The Plumbing Retainer Bar should be on the upper portion of the field of view, so that only the lower half of the gyro is observable. The gyro housing is observed through the lower semicircular hole of the Plumbing Retainer. See Figure 4 below.

Note: The beam from the autocollimator is split into two beams, one covering the upper half, and the other the lower half. Thus it is important that the surfaces to be compared are on separate halves of the field of view.

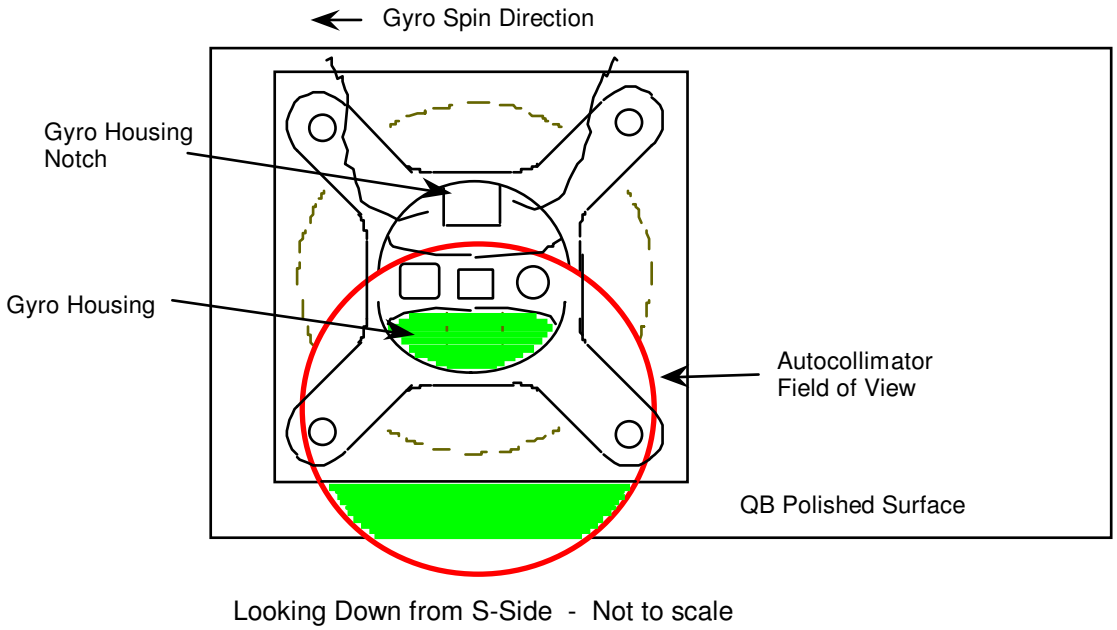

Figure 4. Autocollimator setup without Eyepiece for tilt about a vertical axis

6.1.2 Carefully tape cleanroom paper to the Plumbing Retainer so that only the lower half of the Plumbing Retainer is exposed.

CAUTION: Do not touch the polished surface of the QB

6.1.3 Cover any portions of the field of view which are extraneous or distracting, by blocking corresponding portions of the Autocollimator telescope with paper or tape.

6.2 Measuring the Tilt

6.2.1 Replace the eyepiece, and follow the procedures of P0354 until the relative tilt angle between the QB Polished Surface and Gyro Housing are determined.

6.2.2 Record this tilt angle on the data sheet for that gyro. Each gyro has a separate sheet.

The relative tilt allocation in each direction between the QB Polished Surface and Gyro Housing is 4 arc-sec.

Note: Although 0.1 arc-second accuracy is claimed by the manufacturer, a more realistic accuracy is approx. ± 0.2 arc-second, due to the subjective nature of observations.

7 MEASUREMENT OF TILT AROUND THE HORIZONTAL AXIS

7.1 Masking

7.1.1 Rotate the Autocollimator in the Stand by 90° so that it is supported by the other 3 feet, and the micrometer dial is on the top, as you are looking through the autocollimator.

7.1.2 With the eyepiece removed, fine-adjust the autocollimator height and angle so that a green reflection of the quartz surfaces of the gyro housing and are simultaneously observed. The QB polished surface is to the left or right of the gyro, depending on the gyro. See Figure 5 below.

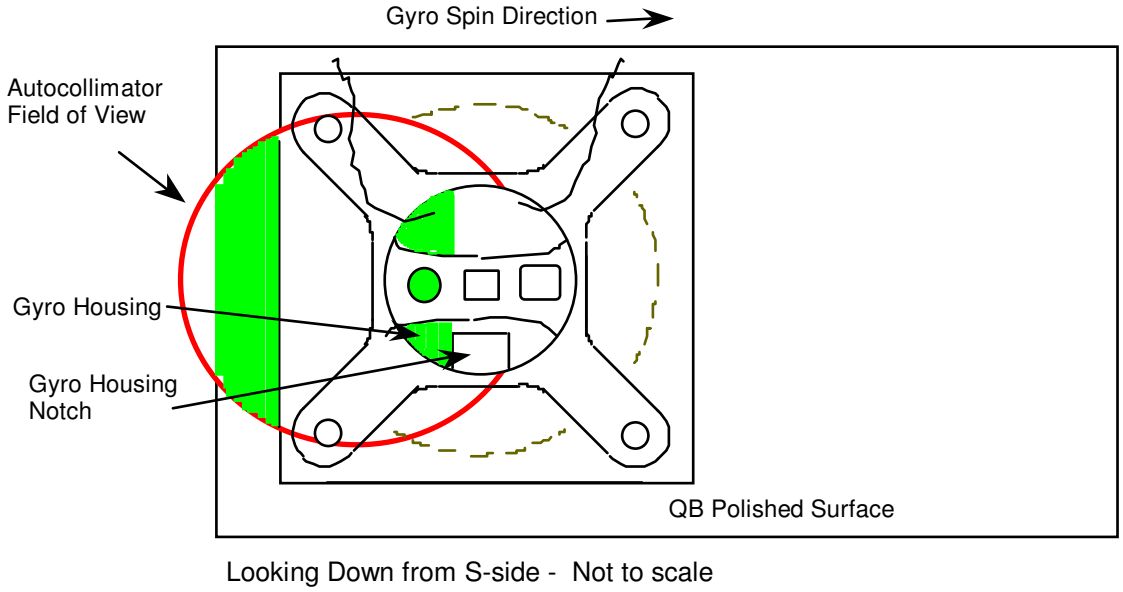

Figure 5. Autocollimator setup without Eyepiece for tilt about an horizontal axis

7.1.3 Carefully tape cleanroom paper to the QB so that only the left half of the Plumbing Retainer is exposed.

CAUTION: Do not touch the polished surface of the QB

7.1.4 Cover any portions of the field of view which are extraneous or distracting, by blocking corresponding portions of the Autocollimator telescope with paper or tape.

7.2 Measuring the Tilt

7.2.1 Replace the eyepiece, and follow the procedures of P0354 until the relative tilt angle between the QB Polished Surface and Gyro Housing are readable off the Autocollimator.

7.2.2 Record azimuth tilt angle on the data sheet for that gyro. Each gyro has a separate sheet.

8 REPEAT SECTIONS 6 AND 7 FOR ALL GYROS

For Gyros 1 and 2, rotate the SIA in the Roller Mechanism such that their bores are parallel to the table, with the gyro's S-side facing the autocollimator. To go from Gyro 1 to Gyro 2, or conversely, move the Autocollimator and Stand in front of the gyro to be measured, and repeat Sections 6 and 7.

For Gyros 3 and 4, rotate the SIA in the Roller Mechanism such that their bores are parallel to the table, with the S-side facing the autocollimator. To go from Gyro 3 to Gyro 4, or conversely, move the Autocollimator and Stand in front of the gyro to be measured, and repeat Sections 6 and 7.

Record the start and completion date for each gyro below.

Record G1 Start Date and Time _____

Record G1 Completion Date and Time _____

Record G2 Start Date and Time _____

Record G2 Completion Date and Time _____

Record G3 Start Date and Time _____

Record G3 Completion Date and Time _____

Record G4 Start Date and Time _____

Record G4 Completion Date and Time _____

9 PROCEDURE COMPLETION

The results obtained in the performance of this procedure are acceptable.

Integration Engineer _____ Date _____

Integration and Test Director: _____ Date _____

The information obtained under this assembly and test procedure is as represented and the documentation is complete and correct.

Quality Assurance _____ Date _____

11 DATA BASE ENTRY

The following data shall be entered into the GP-B Data Base:

1) Name, number and revision of this procedure

2) Date of successful completion of procedure.

3) Serial numbers of the completed assemblies together with S/Ns of their components

4) Tilt measurement information for each completed assembly

5) Any comments providing information for future selection or units for next step.

Gyro Position _____

Date and Time _____

Gyro/ Gyro Housing Serial Number _____

List below the average of at least three tilt measurements for each tilt direction:

Tilt around Vertical Axis: **_____ arc-s**

Tilt around Horizontal Axis: **_____ arc-s**

Completed: _____ Date: _____
Integration Engineer

Discrepancies and resolution, if any:

Disposition and sign-off: _____ Date: _____
ITD

QA acceptance: and sign-off: _____ Date:_____