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Gravity Probe B Relativity Mission

UV CHARGE CONTROL COMMISSIONING PROCEDURE FOR SM GYROSCOPES

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UV CHARGE CONTROL COMMISSIONING PROCEDURE FOR SM GYROSCOPES

This procedure is to be performed only by persons listed as certified operators of the gyroscope acceptance facilities.

ESD precautions: Follow accepted ESD procedures.

OVERVIEW

Due to the extremely small currents possible through UV photoemmission (~ -100 to +10 fA), noise considerations limit performance testing to un-levitated gyroscopes. Net currents to and from the rotor are determined by measuring the current between the ground plane and local ground using an electrometer. The UV fixture is biased with either + 3 VDC, 0 VDC or - 3 VDC to control the net flow of charge.

Equipment needed:

(1) Keithly 6512 (or 617) Programmable Electrometer
(1) Keithly 485 Autoranging Picoammeter
(1) HP E3620A 0-25 V Dual Channel DC Power Supply
(1) JeLite UV source w/power supply or Resonance Ltd. GP-B STU Lamp w/ 30VDC power supply
(2) Resonance Ltd. Cs-Te photodiode (can use only one photo diode if two are not available)
(1) PC w/IEEE and A/D breakout box running Strawberry Tree data acquisition routine
(2) Fiber optic jumpers. One SMA to SMA, one SMA to LEMO.
(2) DiCon fiber optic on/off or 1x2 switch. One with LEMO connectors, one with SMA connectors.

(Note: Section A applies to Room Temperature Commissioning
Section B applies to Low Temperature Commissioning Acceptance Testing)

A. Procedures for measurement of photocurrent in RT3 and RT4

Section AI must be performed prior to installation of the gyroscope in the vacuum can. It is not necessary to calibrate the system at each gyro installation as the system calibration is independent of any particular gyroscope however, the system calibration should be checked (re-calibrated) on a regular basis.

AI - Couple UV source into vacuum can and calibrate the UV feed-throughs

This sub-section verifies the optical paths from the UV source to the gyro and calibrates the UV power at the UV fixture relative to the UV power at the optical feedthrough.

AI-1. There are three fiber optic SMA feed-throughs into the vacuum can. Determine which SMA feed through goes to which LEMO connector inside the can by shining a flashlight through the connector. Label these feed-throughs and the corresponding LEMO connectors in the system notebook as A, B and C. Clean all SMA connectors with ethyl alcohol and dry with a lint free wipe.
AI-2. Power on the lamp and allow to warm for 20 minutes.
AI-3. Couple the UV source (typically JeLite UV lamp or STU lamp) to the Cs-Te photodiode.
AI-4. Bias the diode with -25VDC (BNC connector labeled G).
AI-5. Connect the readout of the diode (BNC connector labeled R) to a picoammeter. The reading from this diode will represent UV power at the feedthrough. Record this value in Table I.
AII-1. Connect a LEMO to SMA fiber jumper to the LEMO connector labeled A which is mounted on the gyro support structure.
AII-2. Disconnect the Cs-Te photodiode from the UV source and connect to the SMA end of the SMA-LEMO jumper on the gyro support structure. Connect UV source to fiber feedthrough A. The reading from the diode represents the UV power at the fixture. Record this value in Table I.
AI-1. Repeat I-3 through I-7 twice more for a total of three feed-through vs fixture power measurements for optical path A.
AI-2. Repeat I-3 through II-8 for optical path B.
AI-3. Repeat I-3 through II-8 for optical path C.

The gyro may now be installed in the vacuum can. The fixtures will be identified by the label of the optical path connected to them as well as their location in the gyro housing ("on scribe" or "off scribe"). Choose the two optical paths with the least loss from feedthrough to fixture (see Table I - UV Feedthrough Calibration) to source the two UV fixtures in the gyro. Note the optical path and bias pin out for each fixture in the system notebook and in Table I. Ring both the bias connections and the ground plane connection and fill out the appropriate sections in table I.

AII - Measure UV Photocurrent

The current from the gyro due to UV photoemmission is determined by comparing an average "light on" reading on the electrometer to an average "light off" reading. Figure 1 shows schematically the electronic set-up for measuring UV charge transfer. The electrometer and picoammeter are read over the IEEE bus. The fixture bias voltage is adjusted manually using the DC power supply. The averaging of the electrometer readings (and the optical switch actuation, if used) are automatically controlled using a PC and Strawberry Tree data acquisition software.

In Figure 1, a (-) current represents electron flow from the onto the rotor from the fixture, a (+) current represents electron flow from the rotor to the fixture.

In order to reduce noise to a minimum, special care should be paid to the grounding and shielding scheme as shown in Figure 1. Elimination of noise sources in the room temperature clean room (such as blower motors, static bars, etc.) will help ensure a low noise environment. Noise levels of 3 to 5 fA have been achieved using the set-up described in this procedure.

Two data files may be generated by the data acquisition software: (1) averaged currents and (2) continuous current. Both of these schemes employ the fiber optic switch.

<u>Averaged currents</u>

With the optical switch open, electrometer readings are collected at a rate of 1 Hz (after a period of 1 data delay) and summed for a period of 1 averaging time. This value is then divided by averaging time - data delay to give an average current measured in the "light off" situation. The optical switch is then closed and an average current is determined for the "light on" situation in the same manner. The difference between these two averages is the current due to the UV light. The averaging time and data delay may be adjusted to give an acceptable error in the measurements.

At least 20 ON/OFF cycles will generally need to be collected to obtain a good average of the net current.

Software parameters:

averaging time	typically between 2 minutes and 30 minutes
data delay	typically 10% of the averaging time (10 s minimum)

file format:

date time lamp off (fA) lamp on (fA) net curr (fA) lamp monitor (nA)

Continuous currents

If there is considerable drift in the current and/or the signal to noise ratio is very small (i.e. on the order of unity) it may be difficult to obtain a reliable value using the "averaged currents" method. The data acquisition routine can also save a continuous record of the electrometer readings. This continuous record may then be reviewed as a strip chart and an average UV photocurrent value may be obtained.

Software parameters:	averaging time	sets ON/OFF cycle, as above
	data delay	N/A
	sampling rate	electrometer sampling rate (typically 1 Hz)

file format: date time current from ground plane (fA)

It is also possible to make a UV current measurement using simply a strip chart and adjusting the bias on the fly to +3, 0 and -3 V. A baseline is generated in the same manner with the UV source off. This method has proven reliable if the drift in the currents readings (directly measurable with the lamp off) is small compared to the UV photocurrent. There is a Strawberry Tree routine available to generate such a strip chart, "STRIP.WBB".

Strawberry Tree Data Acquisition Files

UVTEST.WWB	no lamp monitor (IEEE reading of picoammeter)
UVTEST2.WWB	includes lamp monitor
STRIP.WBB	includes both electrometer and lamp monitor

AII-1. Set-up electronics for monitoring UV current per Figure 1. Note that the PC and Strawberry Tree breakout box should be located outside the clean room, the DC power supply should be located in the gowning room (to be able to make adjustments without entering the clean room) and the electrometer, picoammeter, lamp, Cs-Te detector and optical switch should all be located inside the clean room. The electrometer and DC power supply should be powered on a separate AC circuit from the rest of the components (namely, the power supply for the UV lamp). ***Furthermore, there must be no suspension lines hooked up to the vacuum can as they can act as antennae and couple noise into the system***.

AII-2. Calibrate the lamp monitor by measuring the UV power at the feedthrough relative to the lamp monitor reading using the Cs-Te diode. A series of three readings should be made. Record these in Table 3.

AII-3. If optical switch is used, connect the switch output (SMA) to fiber A (SMA) with a Teflon alignment sleeve or barrel connector with alignment sleeve built-in. Otherwise directly couple the UV source to fiber A. (Here I will call the two fixtures (fibers) used A and B but it is possible that optical path C could be used, in which case the label C would be substituted for the unused fiber A or B).

AII-4. Power down the noise sources (clean room blowers, ion gauge, static bar, air conditioning, lights and any computer monitors located inside the clean room). Log the time each system is powered down in Table 2 - Clean Room System Power Log. There shall be no entry to the clean room with the blowers off until 15 minutes after the blowers have been turned back on. Note that the AC power to the clean room blowers and air conditioning system is accessed from a circuit breaker box outside the clean room. It may be necessary to power down static bars, blowers and air conditioning in the clean room adjacent to the one where testing is being conducted.

AII-5. Adjust the fixture bias to -3 VDC. Start the Strawberry Tree data acquisition routine “UVTEST.WBB” (or “UVSTRIP.WBB” for strip chart data acquisition) and adjust the averaging time and data delay to give the cleanest signal. Input an averaged current and continuous current filename and begin logging data. Record these filenames and software parameters in Table 3 - UV Current Measurement File Log.

AII-6. Repeat III-5 with bias set to 0 VDC.

AII-7. Repeat III-4 with bias set to +3 VDC.

AII-8. Adjust fixture bias to -3 VDC. Turn lamp power off (must be done without entering clean room). Start Strawberry Tree Routine “UVTEST2.WBB” (omits lamp monitor). Collect data as in III-4. Update Table 3.

AII-9. Repeat III-7 for 0 VDC fixture bias.

AII-10. Repeat III-7 for +3 VDC fixture bias.

AII-11. Power on all clean room systems. Update Table 2.

AII-12. After blowers and air conditioning have been on for 15 minutes, enter clean room and connect the optical switch output (or UV source directly) to fiber B. Repeat III-3 through III-10 for fiber B.

AII-13. Disconnect UV electronics and optical circuit and remove from clean room.

AII-14. Process raw data and complete table RT Op#2.

B. Procedures for measurement of photocurrent in LT system

The procedures for measuring UV photocurrent at low temperature in the NLFF probe will follow the room temperature procedures as outlined in sections AI through AIII above, omitting system dependent references (i.e. al references to "clean room", "RT#", "clean room systems", blowers", etc.).

The experimental set-up will closely follow that shown for the RT system in Figure 1. Table 1 - UV Feedthrough Calibration as well as Table LT -Op #6 - UV Current Measurements will be completed for each gyroscope installation.

Section BI must be performed prior to installation of the gyroscope in the vacuum can.

BI - Couple UV source into vacuum can and calibrate the UV feedthrough

This sub-section verifies the optical paths from the UV source to the gyro and calibrates the UV power at the UV fixture relative to the UV power at the optical feedthrough. This system calibration should be done on each gyroscope installation since thermal cycling may significantly change the properties of the fiber optics.

BI-1. There are three fiber optic SMA feed-throughs into the vacuum can. Determine which LEMO feed-through goes to which LEMO connector inside the can by shining a flashlight through the connector. Label these feed-throughs and the corresponding LEMO connectors in the system notebook as A, B and C. Clean all LEMO connectors with ethyl alcohol and dry with a lint free wipe.

BI-2. Power on the lamp and allow to warm for 20 minutes.

BI-3. Couple the UV source (typically JeLite UV lamp or STU lamp) to the Cs-Te photodiode.

BI-4. Bias the diode with -25VDC (BNC connector labeled G).

BI-5. Connect the readout of the diode (BNC connector labeled R) to a picoammeter. The reading from this diode will represent UV power at the feedthrough. Record this value in Table I.

BI-6. Connect a LEMO to SMA fiber jumper to the LEMO connector labeled A which is mounted on the gyro support structure.

BI-7. Disconnect the Cs-Te photodiode from the UV source and connect to the SMA end of the SMA-LEMO jumper on the gyro support structure. Connect UV source to fiber feedthrough A. The reading from the diode represents the UV power at the fixture. Record this value in Table I.

BI-8. Repeat I-3 through I-7 twice more for a total of three feed-through vs fixture power measurements for optical path A.

BI-9. Repeat I-3 through II-8 for optical path B.

BI-10. Repeat I-3 through II-8 for optical path C.

The gyro may now be installed in the vacuum can. The fixtures will be identified by the label of the optical path connected to them as well as their location in the gyro housing ("on scribe" or "off scribe"). Choose the optical paths with the least loss from feedthrough to fixture (see Table I - UV Feedthrough Calibration). Note the optical path and bias pin out for each fixture in the system notebook. Ring both the bias connections and the ground plane connection and fill out the appropriate section in table I.

BII - Measure UV Photocurrent

BII-1. Set-up electronics for monitoring UV current per Figure 1.
BII-2. If optical switch is used, connect the switch output (LEMO) to fiber A (LEMO). Otherwise directly couple the UV source to fiber A. (Here I will call the two fixtures (fibers) used A and B but it is possible that optical path C could be used, in which case the label C would be substituted for the unused fiber A or B).
BII-3. Start the Strawberry Tree data acquisition routine "UVTEST.WBB". (Note; if automatic bias control is used (AUTOUV.WBB) steps BII-4 through BII-9 are handled by the data acquisition system) Adjust the fixture bias to -3 VDC". Adjust the averaging time and data delay to give the cleanest signal. Input an averaged current and continuous current filename and begin logging data. Record in Logbook the filenames and Table 3 parameters
BII-4. Repeat BII-3 with bias set to 0 VDC.
BII-5. Repeat BII-3 with bias set to +3 VDC.
BII-6. Adjust fixture bias to -3 VDC. Turn lamp power off. Start Strawberry Tree Routine "UVTEST2.WBB" (omits lamp monitor). Collect data as in BII-4. Update Table 3.
BII-7. Repeat BII-6 for 0 VDC fixture bias.
BII-8. Repeat BII-6 for +3 VDC fixture bias.
BII-9. Power on all clean room systems. Update Table 2.
BII-10. Connect the optical switch output (or UV source directly) to fiber B. Repeat BII-2 through BII-9 as required for fiber B.
BII-11. Calibrate the lamp monitor by measuring the UV power at the feedthrough relative to the lamp monitor reading using the Cs-Te diode. A series of three readings should be made. Record these in Table 3.
BII-12. Process raw data and complete table LT Op#6.

Analysis of Results yielding noise greater than the expected signal may require, at REE's discretion, steps BII-3 through BII-8 to be run to reduce the noise source.

TABLE 1 - UV FEED-THROUGH CALIBRATION AND CHECK-OUT

Date: ____________
System: ____________

Cs-Te detector used at fixture: ____________ nA/uW S/N ______________
Cs-Te detector used at UV source: ____________ nA/uW S/N ______________

Keithly 6512 (or 617) Electrometer S/N ____________________
Keithly 485 Picoammeter S/N ____________________
HP E3620A DC power supply S/N ____________________

optical path	diode reading at fixture (nA)	diode reading at feedthru (nA)	UV power at fixture (uW)	UV power at feedthru (uW)	ratio (fixture/ feedthru)	avg ratio
A						
B						
C						

fixture location in housing	optical path	bias pin	bias pin to fixture resistance (Ohms)	bias pin to GP capacitance (pF)

Ground plane connection out : ____

Ground plane connection center pin to shield resistance: ____________________________

COMMENTS : ____

____

TABLE 2 - CLEAN ROOM SYSTEM POWER LOG

Date: _____________ Fixture under test: A B C
Clean room used: RT#_________

System	Time Off	Time On	Comment
Static bar			
Ion gauge			
Lights			
Air conditioning			
Blowers			

*** ABSOLUTELY NO ENTRY TO CLEAN ROOM ALLOWED UNTIL BLOWERS HAVE BEEN ON FOR 15 MINUTES.

Date: _____________ Fixture under test: A B C
Clean Room used: RT#_________

System	Time Off	Time On	Comment
Static bar			
Ion gauge			
Lights			
Air conditioning			
Blowers			

*** ABSOLUTELY NO ENTRY TO CLEAN ROOM ALLOWED UNTIL BLOWERS HAVE BEEN ON FOR 15 MINUTES.

TABLE 3 - UV CURRENT MEASUREMENT FILE LOG

Date: _____________ Gyro housing: _____________
System: _____________ Rotor: ____________________
Test # __________

Resonance Cs-Te photodiode: S/N ______________________ (_______ nA/uW)
Keithly 6512 (or 617) Electrometer S/N ______________________
Keithly 485 Picoammeter S/N ______________________
HP E3620A DC power supply S/N ______________________

MONITOR CALIBRATION

UV monitor (nA)	UV @ feedthrough (nA)	ratio (feedthru/monitor)	average ratio

RAW DATA FILES

Fixture A B C S/N:_____________ Location in housing: on scribe / off scribe

Fixture bias (V)	Lamp (on/off)	data filename	Comment
+ 3	on		
0	on		
- 3	on		
+ 3	OFF		
0	OFF		
- 3	OFF		

Fixture A B C S/N:_____________ Location in housing: on scribe / off scribe

Fixture bias (V)	Lamp (on/off)	data filename	Comment
+ 3	on		
0	on		
- 3	on		
+ 3	OFF		
0	OFF		
- 3	OFF		

ROOM TEMPERATURE UV CURRENT MEASUREMENTS
Table RT -Op #2

Date: _____________ Gyro housing: _____________
System: _____________ Rotor: ___________________
Test # _________

Reduced data and summary filenames:____
____

(+) current = electron flow from the rotor to the fixture
(-) current = electron flow from the fixture onto the rotor

Fixture	Bias (V)	net current (fA)	normalized net current (fA/uW)	spec (fA/uW)	pass /fail
A B C	+ 3			> 10	
s/n	0			N/A	
scribe on/off	- 3			> -30	
A B C	+ 3			> 10	
s/n	0			N/A	
scribe on/off	- 3			> -30	

<u>NULL CHECK - LAMP OFF</u>

Fixture	Bias (V)	current (fA)	comment
A B C	+3		
	0		
	- 3		
A B C	+ 3		
	0		
	- 3		

Completed by: ____ on ________________

Witnessed by: ____ on ________________

LOW TEMPERATURE UV CURRENT MEASUREMENTS
Table LT -Op #6

Date: _____________
System: _____________

Gyro housing: _____________
Rotor: ____________________
Test # __________

Reduced data and summary filenames:_______________________________________
____

(+) current = electron flow from the rotor to the fixture
(-) current = electron flow from the fixture onto the rotor

Fixture	Bias (V)	net current (fA)	normalized net current (fA/uW)	spec (fA/uW)	pass /fail
A B C	+ 3			> 10	
s/n	0			N/A	
scribe on/off	- 3			> -30	
A B C	+ 3			> 10	
s/n	0			N/A	
scribe on/off	- 3			> -30	

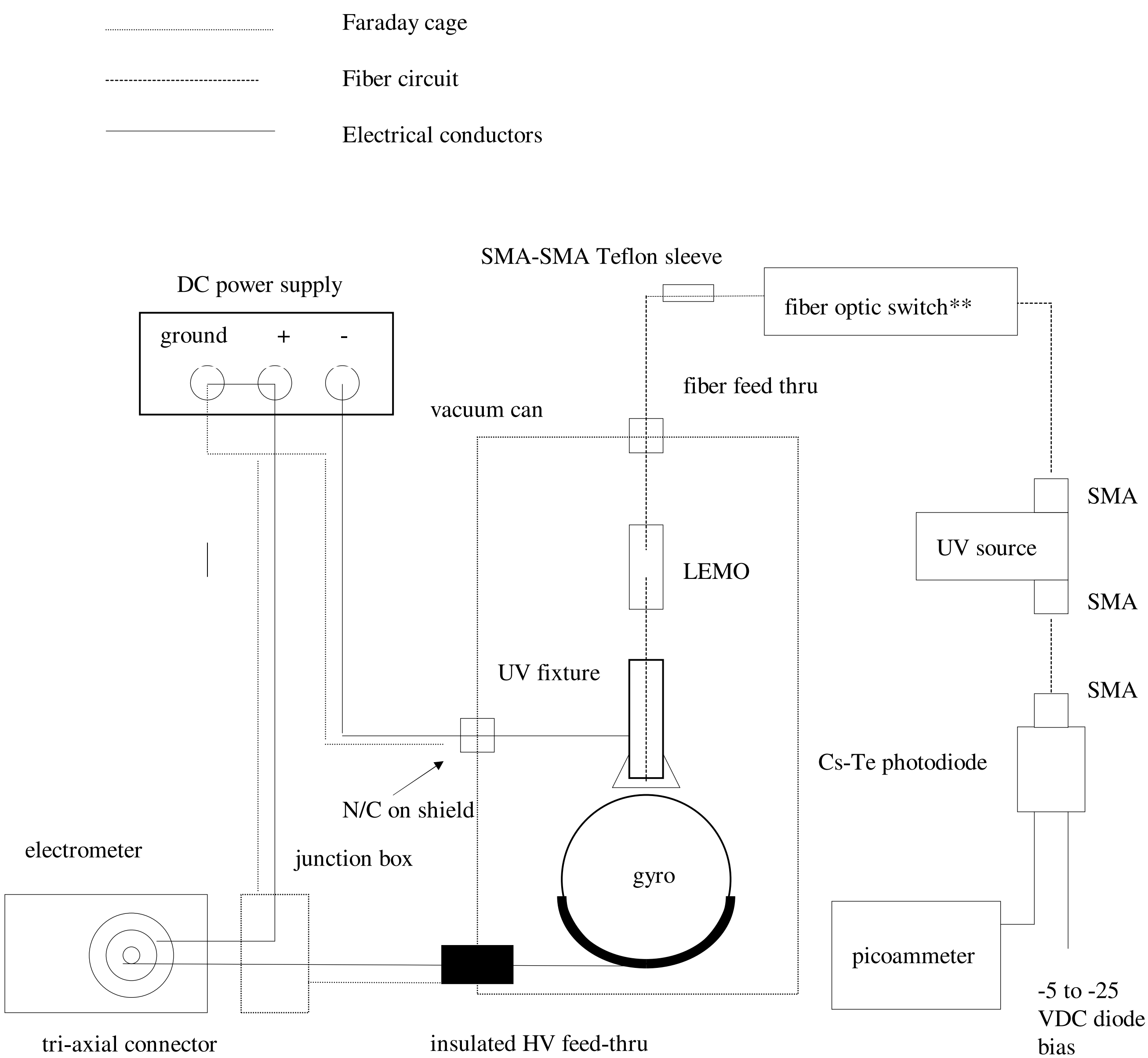
<u>NULL CHECK - LAMP OFF</u>

Fixture	Bias (V)	current (fA)	comment
A B C	+3		
	0		
	- 3		
A B C	+ 3		
	0		
	- 3		

Completed by: ____ on ________________

Witnessed by: ____ on ________________

FIGURE 1 - INSTRUMENTATION SET-UP FOR MEASUREMENT OF UV PHOTOCURRENT



** optional element in optical path. Source may be coupled directly to fiber feedthrough