MODIFIED ROTATION STAGE 02060-097

Spartan Infrared Camera for the SOAR Telescope

Dustin Baker
Edwin D. Loh
Department of Physics & Astronomy
Michigan State University, East Lansing, MI 48824

Loh@msu.edu
517 355–9200 ext 2480

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We measured the looseness and response of the modified rotation stage SN02060-097 at room temperature and 77 K. Looseness, defined as the angle perpendicular to the rotation axis at which the rotation stage resists radial torque, is 1.5 and 0.08 mrad peak-to-peak at 292 K and 77 K respectively. At room temperature, the response κ of the rotation stage to radial torque is 60 μrad/(N-m). At 77 K, $\kappa = 11$ μrad/(N-m) for torque $\tau < 4$ N-m and $\kappa = 4.5$ μrad/(N-m) for $\tau >$ 4 N-m. The rotation stage is tight enough to hold the mirrors and maintain accurate pointing.

1 Purpose

Phytron/Micos PRS110 rotation stages drive all of the mechanisms in the Spartan Camera, and the most exacting mechanisms are those holding mirrors, where the requirement is 12 μrad to maintain pointing within ½ pixel. Micos modified the housing of rotation stage SN02060-097. This test aims to measure the looseness at 77 K.

Biel & Loh 2002[1] measured the prototype, unnumbered rotation stage and found the stage is not loose and the response is 7 μrad/N/m at 77 K and 2 μrad/N/m at 290 K. The procedure for keeping the rotation stage dry is from Brandon Hanold's notes and from Baker & Loh 2005.[2]

2 Method

We measure the tilt of the rotating face of the rotation stage in response to torque. The tilt and torque are perpendicular to the rotation axis.

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[1] Biel, J., & Loh, E., 2002, "Test of the PRS 100 Rotation Stage," www.pa.msu.edu/~loh/SpartanIRCamera

[2] Baker, D., & Loh, E., 2005, "Rotation Stage 02040-075, Spartan IR Camera," www.pa.msu.edu/~loh/SpartanIRCamera

A test jig (Biel & Loh 2002) allows measurement of the tilt and application of torque while the rotation stage is submerged in liquid nitrogen (Figure 1). Two posts, base-forcing and face-forcing, enable application of the torque. The base-forcing post is attached to the base, and the face-forcing post is attached to the rotating face of the rotation stage. Two posts, base-sensing, and face-sensing, enable sensing the tilt of the rotating face. The jig is made of stainless steel to minimize thermal conduction.

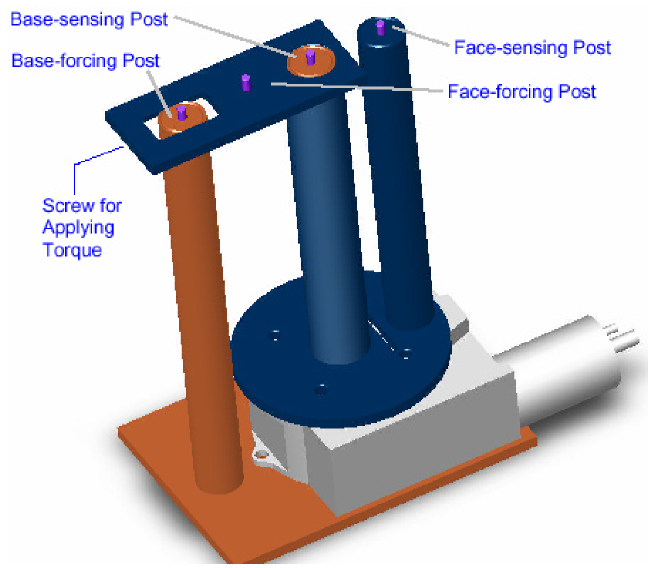

Figure 1 Test jig (picture from Biel & Loh 2002). The base (brown) is bolted to the stationary housing of the rotation stage (grey). The top (blue) is attached to the rotating face of the rotation stage. The rotation stage is submerged in liquid nitrogen, and the tops of the posts are at room temperature.

In order to measure the smaller tilts, we made two significant changes from reference 2. Tooling balls on the top of the posts replace pins. Rather than a micrometer, an IOTA Diamond 01.02 coordinate-measuring machine measures the positions of the tooling balls.

To apply a torque, a weight, which is tied to a string, pulls the face-forcing post to the left in Figure 1 and toward the base-forcing post.

The rotation stage has hysterisis. For the normal measurement, a large negative torque is applied first, and then the positive torque is applied slowly. A few measurements are taken with a large, initially positive torque. With the same final torque, the difference in tilt between initially negative and initially more positive torque indicates hysterisis.

3 Results

The results at room temperature and at 77 K are shown in Figure 2. The definition of the zero angle is slightly complicated because of hysterisis. We define the zero angle so that the tilt with a large negative torque and zero final torque is equal in magnitude (and opposite in sign) to that with a large positive torque and zero final torque.

We define the hysteresis h to be the difference between the angle at torque decreasing to zero and increasing to zero.

At room temperature, the tilt increases steeply with increasing torque up to 0.9 mrad. Beyond that, the system stiffens. We define the tilt at which the system stiffens to be α_0.

Our interpretation is that the bearings of the rotation stage are not engaged for $\alpha<\alpha_0$. When the bearings in the rotation stage are engaged, $\alpha = \kappa\ \tau$, where κ is the response of rotation stage to torque. The response at $\alpha<\alpha_0$ is approximately linear, and we define a response κ_0 for that region.

The peak-to-peak looseness $2\alpha_0$, hysteresis, and response κ for SN02040-075 are summarized in Table 1.

The modified rotation stage 02060-097 has much better performance than 02040-075, one of the original stages. At 77 K, the looseness $2\alpha_0$ is 5 times tighter, the hysteresis h is 30 times less, and the response κ is 9 times better.

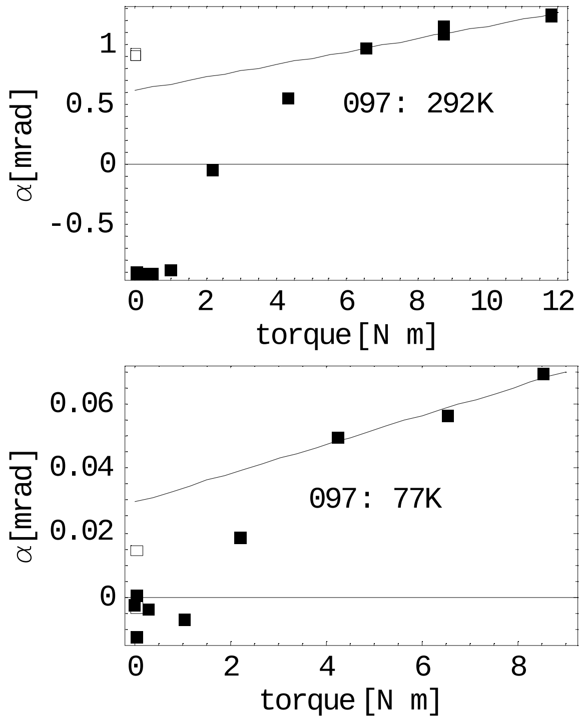

Figure 2 Tilt *vs.* torque at 292 K (top) and at 77 K (bottom). For the closed boxes, a large negative torque was applied first. For the open boxes, a large positive torque was applied first.

Table 1 Parameters of the modified rotation stage 02060-075 and 02040-075, an unmodified stage.

Param					Unit
SN	02040-075		02060-097		
T	292	77	292	77	K
$2\alpha_0$	2.8	0.4	1.5	0.08	mrad
h	0.7	0.34	1.8	0.011	mrad
κ_0	900			11	µrad/(N-m)
κ	60	40	60	4.5	µrad/(N-m)