Keck Adaptive Optics Note 717

Keck 2 Telescope Tube Flexure Measurements

T. Stalcup

Version 1.0 - 9 March 2010

1 Introduction

The design of the beam transport system for the planned NGAO laser projection system will strongly depend on how much elevation dependent telescope tube flexure is present. KAON 210 by Scott Acton details flexure testing between L3 and L4 for the Keck 2 dye laser beam projector performed in May 2001. This testing indicated that there was about 12 mm of motion due to flexure as the telescope is moved from zenith to 10 degrees. This is in contrast to the design value of 1.8 mm for the flexure of the top ring relative to the elevation ring from KOR 90, *The Design of the Keck Observatory and Telescope.* The NGAO system design could potentially be considerably less complex if the flexure was the design value of 1.8 mm versus the earlier measured value of 12 mm, so more testing was desired to determine the correct value. This testing was performed on September 22, 2009.

2 Test Setup

The plan for the test was to attach a laser to the elevation ring and aim it at a target close to the existing L4 lens at the top end of the telescope. A telephoto lens was used to take a picture of the spot on the grid at different elevations. This test had somewhat low precision due to the size of the laser spot on the grid, but since the goal of this test was to determine if the flexure was 2-3 millimeters or 12 the setup was deemed sufficient. An example image of the spot is shown in figure 1. The minor grid lines are 4 mm apart

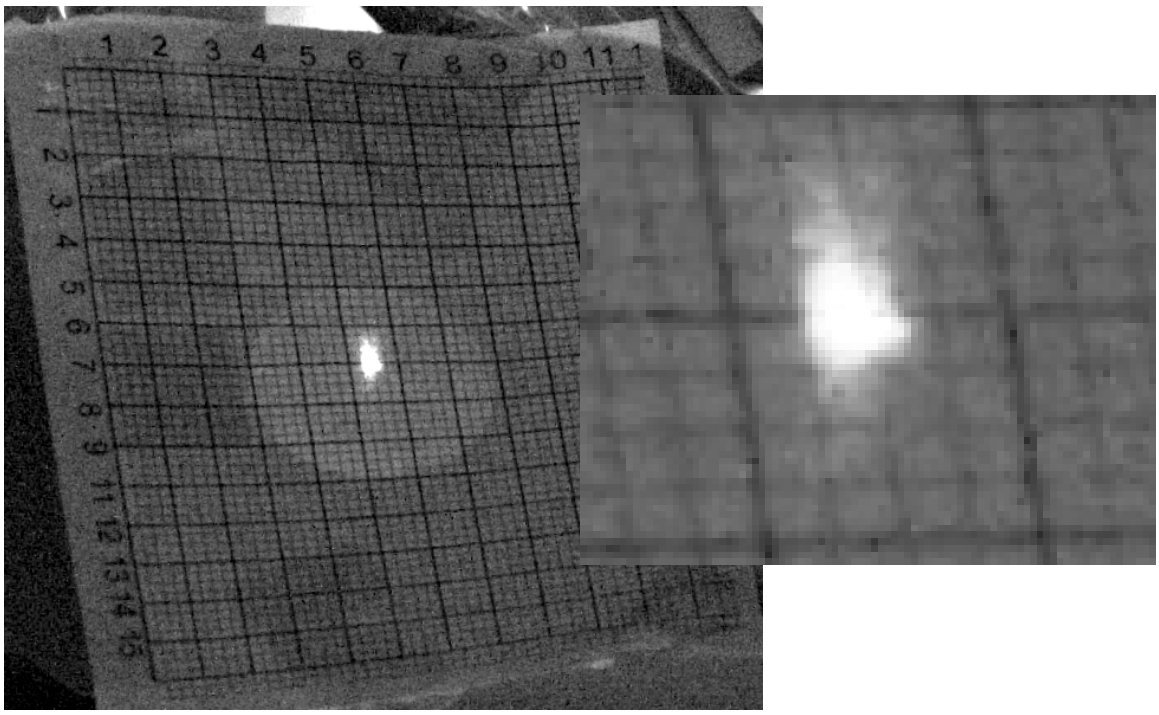

Figure 1. Laser spot on target grid.

3 Results

The centroid of the spot was estimated from the camera images. This was done by visual estimation and not by calculation as the spot core was saturated and also because the change in reflectivity resulting from the black gridlines noticeably changed the shape of the spot which would affect a centroid calculation. Contour lines were added to the spot image to help visually determine the center. The grid axes were aligned such that the long axis of the paper was roughly along the elevation axis. The raw data is in Table 1 while Figure 2 shows an x-y plot of the measured motion.

Table 1. Flexure versus elevation

elevation	long axis mm	short axis mm
23	2.397	1.598
30	2.397	0.799
40	1.598	0.799
50	0.799	0
60	0.799	0
70	0.799	0
80	0	0
90	0	0

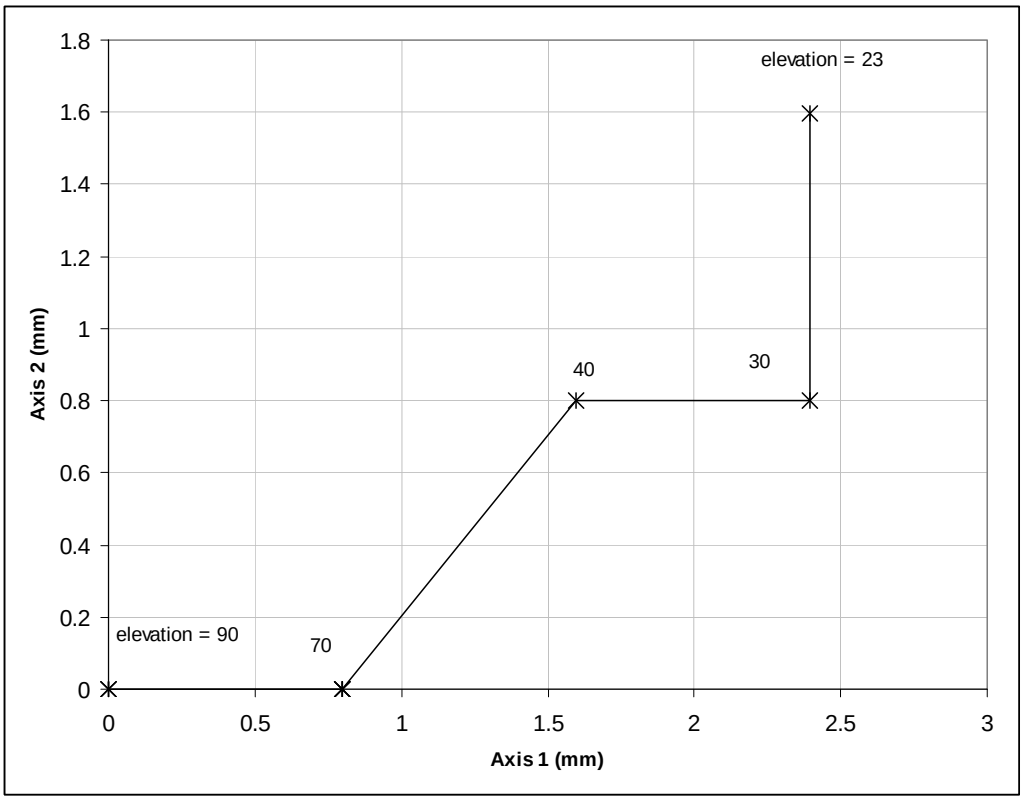

Figure 2. Plot of flexure versus elevation

Note that the total observed motion in either axis was about half of a minor grid square so the uncertainty in this measurement is large. It does, however, provide a reliable upper limit on the amount of flexure which was the main goal of this testing.

4 Conclusion

The total measured flexure was 2.9 mm. This is slightly more than the amount expected from the telescope design manual, but significantly less than that measured previously between L3 and L4 of the current laser projector system. This likely indicates either a problem with the original test setup or, more likely, that the mounts for L3 and L4 are themselves the source of most of the previously measured flexure.