Palomar Beam Transfer Optics Transmission

A. Bouchez, v2: 8/7/06

1. The BTO 594 nm stimulus breadboard

Accurate measurement of the transmission of the beam transfer optics system (BTO) requires an appropriately formatted stimulus beam near the design wavelength of 589 nm. The optical breadboard shown in Figure 1, assembled on 7/26/06 with some modifications on 8/2/06, spatially filters the light of a 594.1 nm HeNe laser and directs a linearly polarized, ~6 mm diameter collimated beam in any output direction. The output power using a 5mW laser is ~2.2 mW in either polarization axis. It has been designed to be compact and portable, such that it can be deployed to either the AO lab, LLT storage room, or Coudé lab.

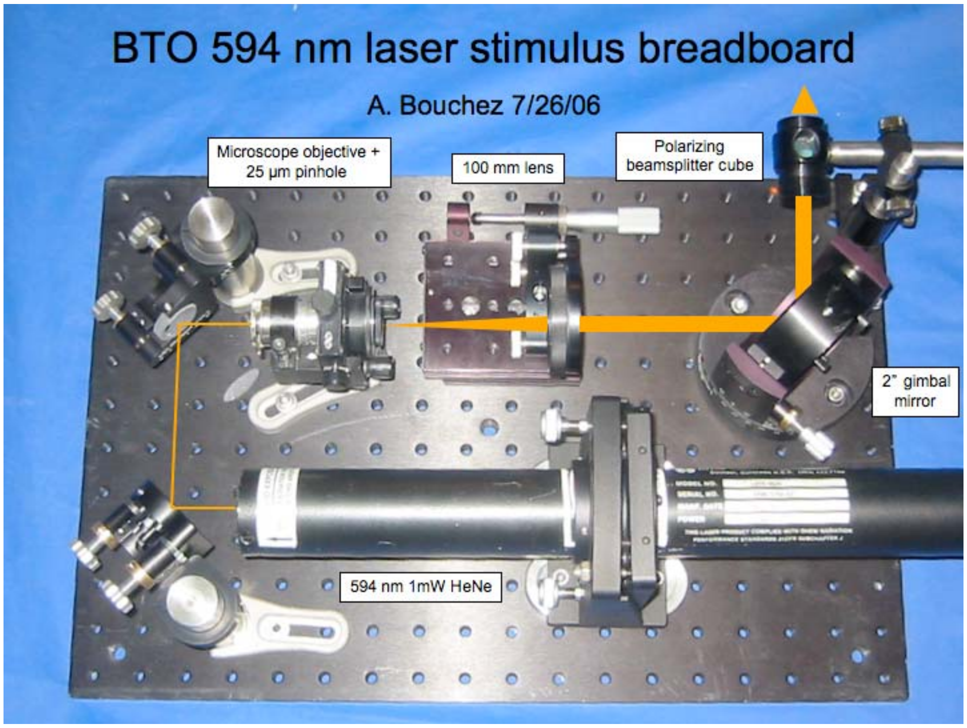

Figure 1: Annotated photo of the 594 nm laser stimulus breadboard. The final gimbal mirror directs a 2.2 mW, ~6 mm diameter collimated and linearly polarized beam in any direction.

2. Measurement of BTO optics in the Coudé lab

The transmission of the BTO optics in the Coude lab was measured by A. Bouchez and A. Moore on 7/25/06 without the help of the stimulus breadboard described in Section 1. Instead, we mounted the unpolarized 1 mW, 594 nm wavelength HeNe laser on the BTO optical bench, parallel to and immediately below the 660 nm fiber laser, using a 25 μm pinhole and an F = 50.2 mm lens to launch a ~4 mm diameter beam onto the axis of the Chicago laser output. A polarizing beam-splitter cube was placed in the notch at the edge of the steel platform to reject all but horizontally polarized light before the beam reached the first BTO mirror (M1a). The measurements are summarized in Table 1. The transmission of the BTO optics in the dome could not be accurately measured due to higher than expected beam divergence, which caused the stimulus beam to overfill the sensor head. The measurements should be repeated with the new 594 nm stimulus.

Location (after optic)	Power (μW)		
	run 1	run 2	run 3
Input	296	289	283
M1a	289	276	
B-S cube	280	276	
M1b (Coude FSM)	256	248	240
1/2 wave plate	250	249	236
Coude window			238

Table 1: Coude lab transmission measurements made on 7/25/06.

3. Measurement of LLT optics

The transmission of the LLT optics was measured on 8/2/06, using the 594 nm stimulus breadboard mounted on a stand in the LLT storage room. The collimated beam was directed onto the top fold mirror of the LLT (M4), and power measurements were made after each optic up to the LLT secondary. The reflectance of the LLT primary, secondary, and M6 (old and new) were measured separately, by directing the collimated beam onto the surface of each optics and measuring power the power just before and after the reflection. The measurements are summarized in Table 2.

Location (after optic)	Power (mW)					
	run 1	run 2	run 3	run 4	run 5	run 6
Input	2.14	2.19	2.19	2.22	2.22	2.18
M4	2.14	2.16	2.15			2.15
Q3 B-S	2.09	2.10	2.10		2.14	2.09
M5 (FSM)	1.98	1.98	2.00	2.00	2.04	1.98
lens + M6			1.70	1.70	1.77	1.72
1/4 wave plate					0.53	0.52
Input	2.13	2.13	2.13			
LLT secondary	2.09	2.10	2.10			
Input	2.17	2.16	2.15			
LLT primary	1.95	1.94	1.94			
Input	2.16	2.15				
M6 only	1.95	1.96				
Input	2.24	2.23				
new M6 only	2.22	2.22				

Table 2: LLT transmission measurements made on 8/2/06

4. Results

The computed reflectivity of each optic in the BTO is shown in Table 3. Using estimates for the three optics not yet measured, I find a total transmission of the BTO of only 17%. This is somewhat lower than the 25% value measured by R. Dekany and E. Kibblewhite on the night on 7/13/06, but probably within their range of uncertainty.

Optic	Transmission	Comments
M1a	0.967	May need cleaning
B-S cube	0.984	
M1b (Coude FSM)	0.902	New mirror on order (est. R=0.98)
1/2-wave plate	0.988	
Coude window	0.993	
M2 (trolley)	0.980	Estimated
Q1 b-s	0.975	Estimated
M3 (boresight)	0.990	Estimated
M4 (top fold)	0.989	
Q3 b-s	0.975	
M5 (LLT FSM)	0.946	Needs cleaning
LLT lens	0.946	Needs A/R coat?
M6 (bottom fold)	0.907	Damaged. Replaced with R=0.993
1/4-wave plate	0.305	Damaged. Removed on 8/2/06.
LLT secondary	0.984	
LLT primary	0.900	Below specifications (>0.96)
End-to-end	**0.168**	Design goal: 0.75

Table 3: Transmission of each optic in the BTO. Values highlighted in red are of concern. Optics which have not yet been measured are estimated in blue.

Of the BTO optics measured, 4 have transmissions well below 95%: The Coude FSM, M6 (the LLT bottom fold mirror), the ¼-wave plate, and the LLT primary. The low reflectivity of the diamond-turned aluminum surface of the Coude FSM measured here is roughly consistent with the value of 89.1% measured by C. Shelton at 660nmon 5/17/06. A replacement broadband dielectric mirror is already on order, and may arrive in time for installation before the September 2006 LGS run.

The low transmission of M6 and the ¼-wave plate was a surprise, and inspection of these optics revealed damage due to laser ablation of the plastic retaining ring of the wave plate. Both optics were therefore removed on 8/2/06, and M6 was replaced with a spare (measured reflectivity R=0.993). The damage probably occurred when the LLT FSM was in its powered-off position (at which time it points *north* with respect to the LLT optical axis). The waveplate needs to be replaced, and masks built to protect mounts (and the back of the primary) from inadvertent illumination.

Once the above three changes have been made (replacement of the Coude FSM, M6, and the ¼-wave plate), the end-to-end transmission of the BTO will be approximately 0.64. This is still below the design goal of 0.70. To reach this goal will require implementation of optics covers and regular cleaning, and probably replacement or recoating of M5, the LLT lens, and the LLT primary.