DESIGN OF THE LYOT STOPS

Spartan IR Camera for the SOAR Telescope

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1 Requirements

Placed at the image of the primary mirror of the telescope, a Lyot stop blocks light that does not come from the primary mirror. The diameter of the f/12 stop is about 39mm. Table 1 summarizes the effects and the expected loss in the limiting magnitude due the each effect.

Table 1 Design parameters and their ettect on limiting magnitude at an ambient temperature of 10 C.

	Effect	Assumption		e	mag	
					K	J & H
1	M1-M3	emissivity per surface	0.02	0.059	0.224	0.033
2	Dichroic			0.020	0.076	0.011
3	Spider obstruction	thickness	25.4 mm	0.016	0.060	0.009
4	M1 central hole	diameter	680 mm	0.028	0.105	0.015
5	Total, ideal			0.117	0.465	0.068
6	M2 blocker support	width	0.30 mm		0.008	0.000
7	Misalignment tolerance	at stop	0.2 mm	0.006	0.004	0.000
		instrument tilt at ISB	5 mrad			
		shim at ISB	3 mm			
8	Undersize		0.5 mm		0.014	0.000
9	Thickness		0.5 mm		0.002	0.000
10	Undersize for pupil shift				0.032	0.000
11	Total as designed	tight stop for K, loose for J & H			0.435	0.068
12	Oversize to pass all fields	Increased area	12%		0.424	0.000

The Lyot stop is particularly important in the K band where thermal radiation from the parts off the edge of the mirror would increase the background very significantly. If the stop were 2.2 mm larger, the thermal radiation from a 110-mm wide ring around the primary would enter and raise the detection limit in the K band by 0.3 mag. In this and other estimates for the K band, the ambient

temperature is 10 C, and the sky background is that at Mauna Kea with the Mauna Kea filter set,[1] which we use. The emissivity of the mirrors is that of aluminum. The emissivity of the dichroic filter is assumed to be 2%.

In the K band, both the loss of light and increase in background reduce the magnitude, whereas only the loss of light affects the magnitude in the J and H bands.

We require that the Lyot stop mask the central, blackened hole in the primary mirror. In the K band, the detection limit is 0.46 mag brighter due to thermal emission and losses listed in lines 1–4 of Table 1. Except for the central hole in the primary mirror, the other effects are unavoidable. The effect of the central hole increases with the ambient temperature (Figure 1).

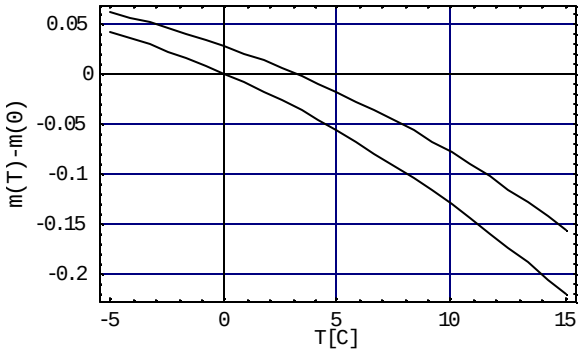

Figure 1 Limiting magnitude vs temperature in the K band with no blockage of the secondary (lower curve) and with the secondary blocked.

The stop for the K band must be undersized to block off-pupil light for all fields. The image of the primary mirror shifts slightly with the field. With an oversized stop larger enough to pass the light from all fields, the detection limit is 0.43 mag brighter in the K band (line 12 in Table 1).

In the J and H bands, there is no reason for using a stop since thermal radiation is negligible. We will use an oversized stop without a central blockage.

2 Design

The Lyot stop is a single piece of aluminum (Figure 2). The opening, central blockage, and spider are cut with an electrical discharge machine.

Several effects cause a loss of efficiency. The spider blocks a small amount of light (line 6 of Table 1). If the stop is misaligned by 0.2 mm, the loss in magnitude is 0.004. The diameter of the stop is undersized by 0.5 mm (1.3%) so that alignment is not difficult. The thickness of the stop

[1] Simons, D A, Tokunaga, A, 2002, PASP 114, 169.

means the stop blocks an extra amount of light. The largest effect is the shift in the pupil with field (0.32 mag, line 10 of Table 1). In summary the detection limit is 0.42 mag brighter in the K band.

The loose stop for the J and H bands is oversized, and it has no central obscuration. In summary the detection limit is 0.07 mag brighter in the J and H bands because of various obscurations, and engineering details of the Lyot stop.

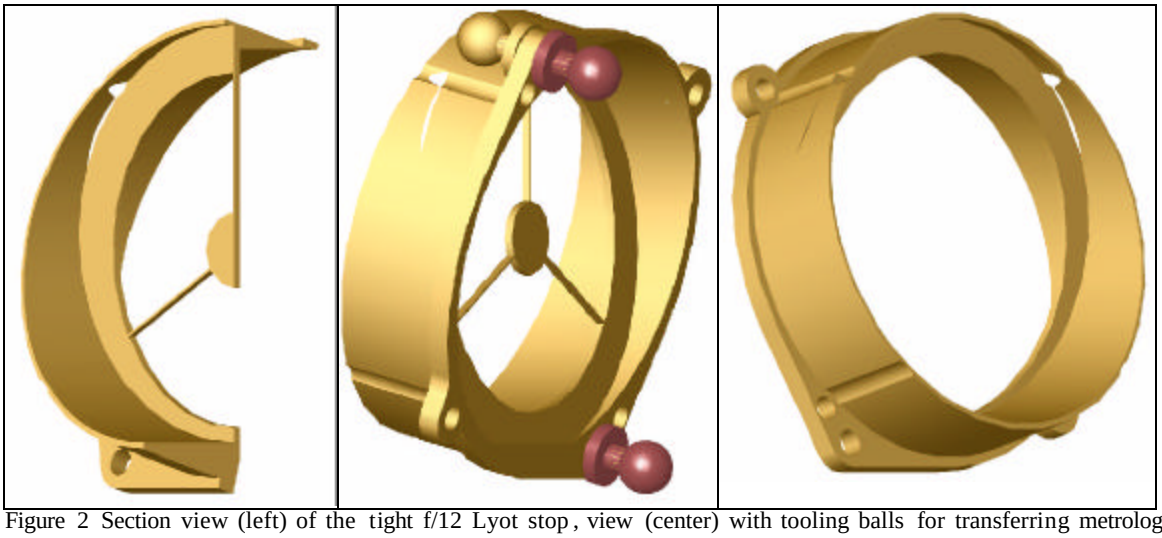

Figure 2 Section view (left) of the tight f/12 Lyot stop, view (center) with tooling balls for transferring metrology between the mounting surface and the tipped stop, and loose f/12 Lyot stop (right). The spider is 0.4×1.0 mm in cross section.

Table 2 Lyot stops The stops are 0.4% oversized at room temperature so that they will shrink to the right size at 77 K.

	@292 K		Sized for 77 K		Over/under size	
Loose f/12	Outer	Inner	Outer	Inner	Outer	Inner
Shift of rim way from ISB	0.330		0.332		0.332	
Major axis	42.889		43.057		43.557	
Minor axis	42.024		42.189		42.689	
Tight f/12						
Shift of rim way from ISB	0.446	0.446	0.448	0.448	0.448	0.448
Major axis	41.020	8.068	41.181	8.100	40.681	8.600
Minor axis	39.238	8.218	39.392	8.250	38.892	8.750
Loose f/21						
Shift of rim way from ISB						
Major axis						
Minor axis						
Tight f/21						
Shift of rim way from ISB						
Major axis						
Minor axis						