IMPROVED COUDE EFFICIENCY OF EXISTING TELESCOPES

W.A. Grundmann and E.H. Richardson
Herzberg Institute of Astrophysics
Dominion Astrophysical Observatory, Victoria, B.C.

ABSTRACT: The ordinary coudé train has a single, large, aluminum coated mirror at each reflection point. This introduces considerable light loss because several reflections are required, and the long light path in turbulent air blurs the stellar image by telescope "seeing" effects. The transmission can be increased and the blur decreased by a train of small mirrors with high reflectance coatings. The high reflectance coatings have the added advantages that they can reduce polarization effects and flatten response curves.

1. INTRODUCTION

In 1969 the 48-inch (1.2 metre) telescope at the Dominion Astrophysical Observatory, Victoria, Canada, was converted to a small-mirror coudé, and equipped with image slicers (Richardson et al., 1971; Richardson, 1972). This resulted in a speed gain that made it faster than the 200 inch (5 metre) telescope at coudé dispersions of 7 and 2.4 Å/mm (Richardson et al., 1971; Richardson, 1971). There are three mirrors, coated for different spectral regions, at each reflection point. Since then the Canada-France-Hawaii Telescope was designed from the beginning to have a small-mirror coudé. Recently a design has been completed to convert the 2.2 metre telescope of Leoncito Observatory, Argentina, from a conventional to a high-reflectance, small-mirror system, and is the subject of this paper.

2. OPTICAL DESIGN

The solution recommended is to use the existing upper end, with the existing coudé secondary mirror refigured to be identical to the existing Cassegrain secondary mirror. The existing two-position flip-cage then permits interchange between high reflectance mirrors for two spectral regions for the Cassegrain as well as the coudé focus. For the latter, the secondary mirror must be defocussed by 90mm, which is within the range of the existing mechanism, and suitable small lenses

C. M. Humphries (ed.), Instrumentation for Astronomy with Large Optical Telescopes, 61–66.

TABLE 1

OPTICAL PARAMETERS FOR SMALL-MIRROR COUDE USING EXISTING CASSEGRAIN SECONDARY MIRROR FOR LEONCITO TELESCOPE

Field: 1 arcmin Units: mm. Flat mirrors omitted

Element	Radius of Curvature	Axial Separation	Medium	Clear Aperture	Comments
Primary	-11176.	-4140.*	Air	2150.	Conic constant = -1.0712
Second	-4430.8	4452.6	Air	561.	cc = -4.322
First Lens	72.92	10.	BaK5	60.	Convex
	67.59	10.	CaF2	60.	
	-103.93	10.	BaK5	60.	
	677.24	6079.	Air	60.	Concave
Field Mirror	-6058.6	6426.	Air	146.	Tilted 4.46 deg. concave 5th mirror
Second Lens	708.1	10.	BaK5	38.	Convex
	324.8	10.	CaF2	38.	
	-305.3	10.	BaK5	38.	
	-597.8	1016.9	Air	38.	Convex
Prism-lens	587.8	55.	Fused-silica	23.	Convex
	Flat	-55.		23.	Tilted 75 deg. for int. reflection
	1953.3	-1.	Air	23.	Convex
Focal surface	Flat			19.7	

*89 mm further from primary than for Cas focus.

and mirrors installed to bring the light to a sharp focus at the coudé. This approach minimizes the amount of physical change to the telescope, is the least costly, will take the least amount of time for conversion and can all be readily accomplished without extensive rework. Figure 1 shows the optical diagram and the locations of the mirror and lens turrets in the coudé train. By utilizing 45mm shims the upper end would be displaced outwards to give a new primary to secondary mean

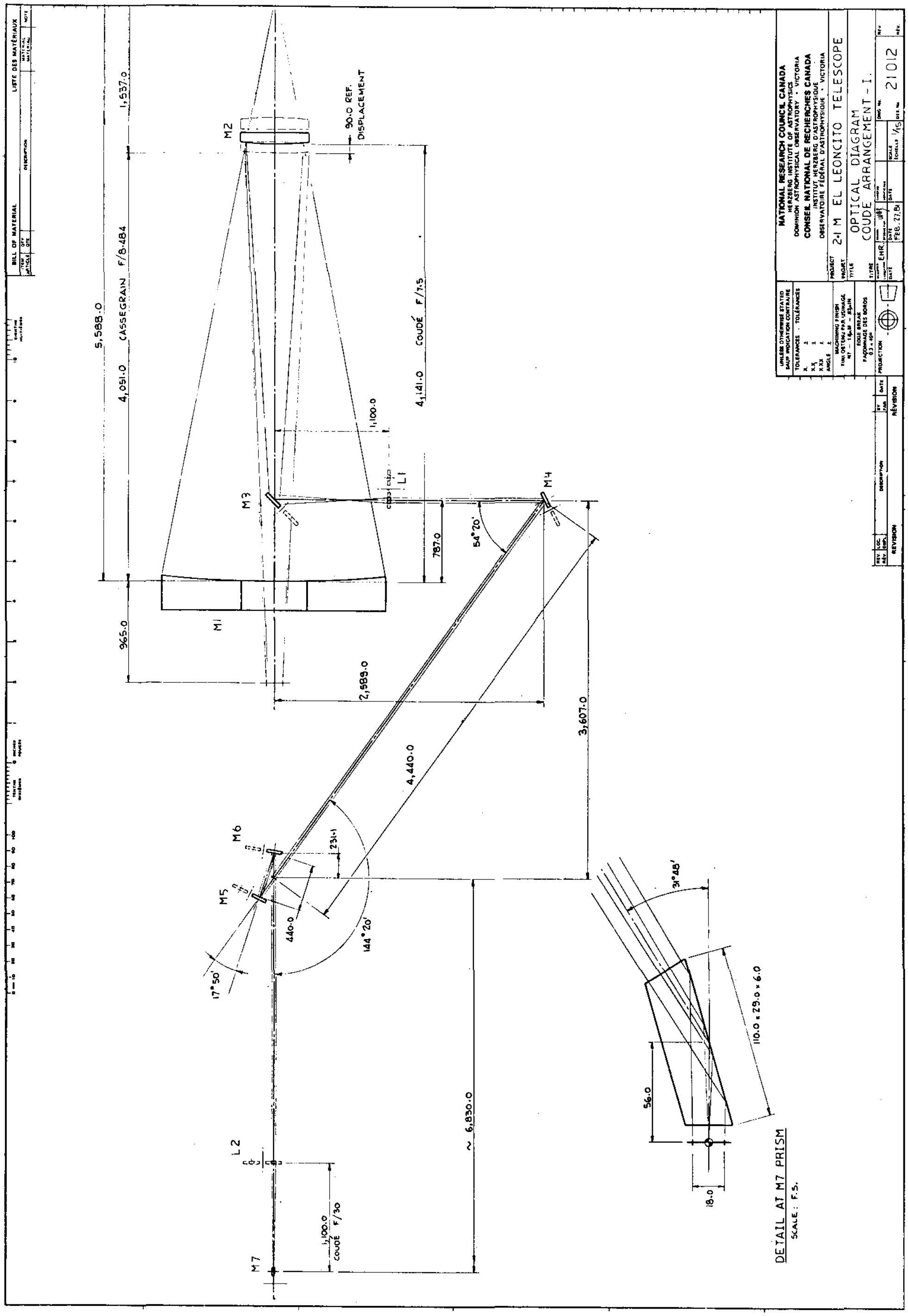

Figure 1. Optical layout of converted Leoncito telescope coudé

TABLE 2

OPTICAL PARAMETERS FOR SMALL-MIRROR COUDE USING A NEW SECONDARY MIRROR FOR THE LEONCITO TELESCOPE

Field: 1 arcmin Units: mm. Flat mirrors omitted

Element	Radius of Curvature	Axial Separation	Medium	Clear Aperture	Comments
Primary	-11176.	-5200.*	Air	2150.	cc = -1.0712
Coudé Sec	-806.2	12061.6	Air	152.	cc = -1.
Field mirror	7332.7	5198.8	Air	50.	Concave 6th mirror tilted
Lens	110.0	10.	BaK5	66.	Convex
	226.7	10.	CaF2	66.	
	-998.6	10.	BaK5	66.	
	132.7	1804.2	Air	66.	Concave
Prism-lens-reflector	590.3	55.	F.S.	23	Convex
	Flat	-55.	F.S.	23.	Int. reflecting
	-1958.1	-1.	Air	23.	concave
Focal surface	Flat			19.8	

distance of 4,096mm. The existing plus/minus 50.8mm focus adjustment would still achieve the 4,051mm distance for the Cassegrain mirror and the 4,140mm distance for the coudé mirror. The optical parameters are given in Table 1.

A much more expensive alternative is to build a separate upper end for the coudé. The advantages are that more than two of these small secondary mirrors can be carried, thus providing a greater choice of high reflectance coatings, that sharper off-axis images result at the coudé focus, and that there is less central obstruction in the telescope (which is large anyway because of the large hole in the primary mirror). The optical parameters are given in Table 2. In our opinion, these advantages are minor compared with the additional time, cost, and inconvenience of having interchangeable upper ends at this stage in the project. A small-mirror upper end, for coudé secondaries and a wobbling infrared secondary, remains an option for the future.

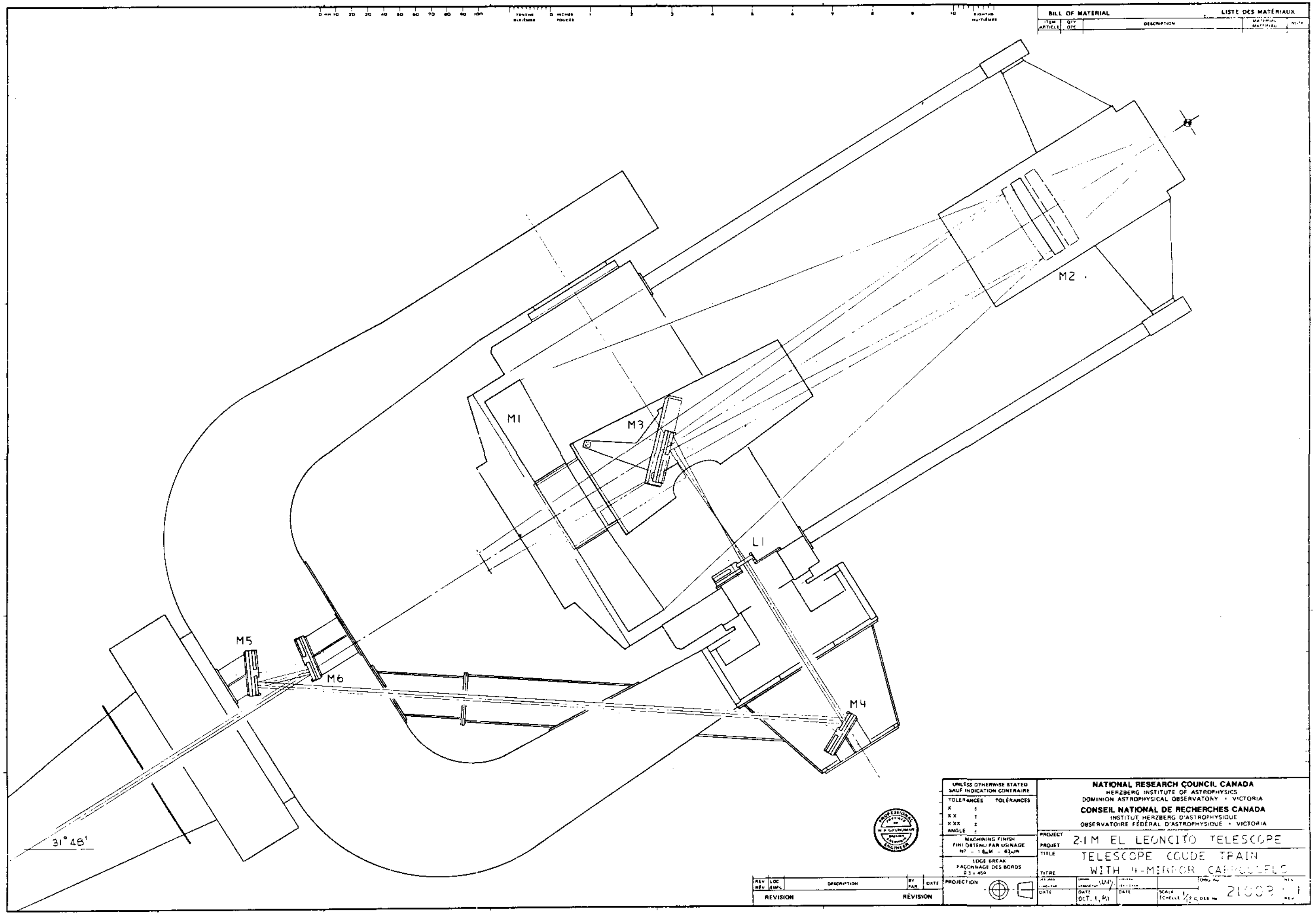

Figure 2. Telescope with 4-optical-element carousels

After the existing secondary, two-position, flip-cage, each new turret or carousel will have room for four sets of optics coated for different spectral regions, such as red, blue, UV, and "super blue" which is an all-dielectric coating (without the metal base of the other coatings which eventually corrode). The light is reflected into the polar axis at a high angle of incidence which would require a turret of elongated mirrors to cover the same field as would be covered by the preferred option of having two turrets of the smaller mirrors operating at lower angles of incidence as shown in Figures 1 and 2.

3. MECHANICAL DESIGN

Six turrets or carousels, each having four optical elements, would be required by the coudé beam. All will be motor driven and will be electrically wired so that on a single command all carousels will rotate and index for the selected spectral region. The M3 carousel in Figure 2 is of a compact size so that it will fit into the existing space of the first coudé flat. This carousel would employ mirrors of 178mm diameter, polished flat to 1/4 wave. The carousels to be employed at all other locations can be equipped with either four mirrors of 152mm diameter or four corrector lenses of 75mm diameter fitted with 152mm adaptor frames. The design solution provides for parts of standardized design and component interchangeability. All carousels employ a single 27.5 VDC gearmotor, and position indexing is accomplished by two-stage switching; the first switch reduces the revolving speed and the second switch stops the rotor and indexes. M7 is a small internally reflecting prism-lens which reflects the light onto the horizontal axis of the coudé spectrograph. It would be used with a mechanical slit only and we recommend that it be interchanged manually because of its accessibility and small size. The function of this reflecting prism will be incorporated in the design of special image slicers for this telescope. Exclusive of installation and electrical controls we estimate that the system described would cost about $110,000 U.S.

It is our objective to make this 2.2 metre telescope in Argentina faster at the coudé than the 3.6 metre telescope in Chile.

REFERENCES

Richardson, E.H., Brealey, G.A. and Dancey, R. 1971, Pub. Dom. Astr. Obs., XIV, pp. 1-15.
Richardson, E.H. 1971, Proceedings of ESO/CERN Conference on Large Telescope Design, ed. R.M. West, pp. 179-193.
Richardson, E.H. 1972, Proceedings of ESO/CERN Conference on Auxiliary Instrumentation for Large Telescopes, ed. S. Laustsen and A. Reiz, pp. 275-284.