Nordic Optical Telescope

Aluminisation and cleaning experiments of the primary mirror, May 1997

Hugo E. Schwarz, August 31, 1997

1 Introduction

The NOT primary mirror (M1) was re-aluminised on the 20th May 1997, in the vacuum tank of the WHT building.

As the time for aluminising the NOT primary mirror approached, some ideas on mirror cleaning were considered. The last aluminisation took place in June 1995, less than two years ago, and a visual inspection of the surface in early May 1997 showed a lot of dust, yellowish spots of lowered reflectivity, and a general mottled pattern of what looked like very fine dust particles. By looking at certain angles along the surface, a strong scattered light component could be discerned. The day before the mirror was to be removed, we did several cleaning experiments on the mirror, which are described in this document.

The aluminisation itself was performed following the detailed instructions in the document: **Mounting and dismounting the NOT primary mirror**. Some improvements were made to this document, mainly order of procedures, to increase efficiency. No problems occurred and the whole procedure went smoothly, and within the time allowed. It was the first time that the aluminisation was done without a team from Risoe helping. For possible help with optics alignment after re-installation in the telescope, T.Korhonen spent some days at the observatory.

Two reflectometers (scatterometers) were used for measuring the reflectivity of the mirror surface before and after each cleaning operation. We borrowed a commercial unit from the ING observatory and constructed one ourselves. The commercial unit uses a laser at 670nm and our unit a LED with a peak emission at 470nm, giving us two wavelength points to compare. In addition, images were taken using a pupil imaging lens in ALFOSC; using a bright star to investigate the reflectivity, and using scattered moonlight to look at the scattered light.

2 Cleaning experiments

Before the mirror was taken out, the following cleaning procedures were performed.

1) Carbon dioxide snow cleaning, using the pressure hose equipment from the ING.

2) Several wet and dry cleaning techniques were tried on small patches of the mirror, using distilled water, dilute anorganic acids, and tomatoes.

After lowering the mirror onto the observing floor, a larger patch was cleaned using a combination of methods.

2.1 CO_2 cleaning.

On the day before the mirror had to come out of the telescope, we cleaned the whole mirror except for one quarter section for comparison purposes. The humidity at 77% was higher than the maximum recommended 50% for CO_2, and the results of the first dry clean were not very good. Some white deposits appeared and the snow stuck before falling along the mirror surface. By measuring the reflectivity avoiding these spots we attempted to get an idea of the possible improvement in reflectivity. The humidity dropped somewhat during the afternoon and a second clean was done at RH=60%. The two sets of results are shown below. There is an overall improvement in reflectivity in the red of 3.3%, and in the blue of 4.8%. Clearly, the clean at 60% humidity was more effective than the one at 77%. After the wet cleaning, the humidity dropped and a third clean was done, results also shown below. Cleaning using this method should only be done when the humidity is below about 40%, otherwise the efficiency is low.

```
 Original reflectivity: 73.0% (red) and 69.2% (blue)
After 1st CO2 clean: 73.3% (red) and 71.4% (blue) (humidity=77%)
After 2nd CO2 clean: 76.3% (red) and 74.0% (blue) (humidity=60%)
After 3rd CO2 clean: 79.4% (red) and 75.7% (blue) (humidity=<8%)
```

2.2 Wet cleaning

After the CO_2 cleaning, we experimented with various wet cleaning techniques on small patches of the mirror. Six different methods were used with the mirror in the telescope and all gave marked improvement of both the reflectivity and scattered light emission. The measurements showed the following results:

	dry rub	tomato+rub	tomato	HCl	HNO3	H2O	before
Red results	82.2	84.1	84.9	82.8	83.4	83.2	73.3
Blue results	80.8	81.7	82.8	82.8	83.4	82.4	71.4

The improvement by wet cleaning is about 10% for both blue and red reflectivity. Note that these methods can be applied to the whole mirror surface with the mirror in place in the telescope.

The reflectivity image of the primary mirror is shown in Figure 1.

Scattered light is also of importance, and conventional wisdom has held that any contact method of cleaning the aluminium surface of a mirror would result in an increase in the number of small scratches and hence increase the scattered component. Figure 2 shows that the scattered component has in fact decreased dramatically (about a factor of 5) in the cleaned patches as compared to the rest of the mirror. The untouched part of the mirror (on the right side of Figure 2) has the highest scattered light emission, indicating that even CO_2 cleaning reduces the scattered component albeit by a small amount. Compare the covered strip of the telescope aperture with the cleaned patches. Near original scattering performance is reached after cleaning.

The larger patch that was cleaned by wetting with distilled water, washed with nitric acid, and then rubbed with tomatoes, gave a reflectivity similar to the best wet cleaning results above.

On the 7th of July 1997, about 6 weeks after re-aluminisation, the mirror was CO_2 cleaned under conditions of very low humidity. The reflectivity was restored to within 0.4% of that of the reference flats which are stored in a clean environment. An increase of 1.3% was noted after cleaning. The results are summarised below:

```
All measurements taken at 470nm with the NOT reflectometer.

Reference flat: 85.4%
Primary mirror: 83.7% before cleaning.
Primary mirror: 85.0% after cleaning.

Visual inspection before cleaning showed some loose dust, a hair, and
some blue paint flakes. After cleaning the mirror had a generally
clean aspect.
```

3 Conclusion

Wet and CO_2 cleaning of the mirror can improve the performance of a 2 year old dirty surface by an important amount, both in reflectivity and in scattering. Freshly deposited dust can be nearly completely removed by dry cleaning, and wet cleaning at longer intervals can likely keep the surface clean, highly reflective and of low scattering intensity over several years.

The methods will be used to prolong the intervals between mirror aluminisations at the NOT. We estimate that we could, without loss of performance, increase the time between successive aluminisation from 2 to 5 or 6 years. At a cost per aluminisation (at 1997 prices) of 400kSEK, this represents an annual saving of about 130kSEK. In this cost are included the 10 nights of lost observing time, but not the risk to the mirror during the complex aluminisation procedure, and its transport to and from the WHT building.

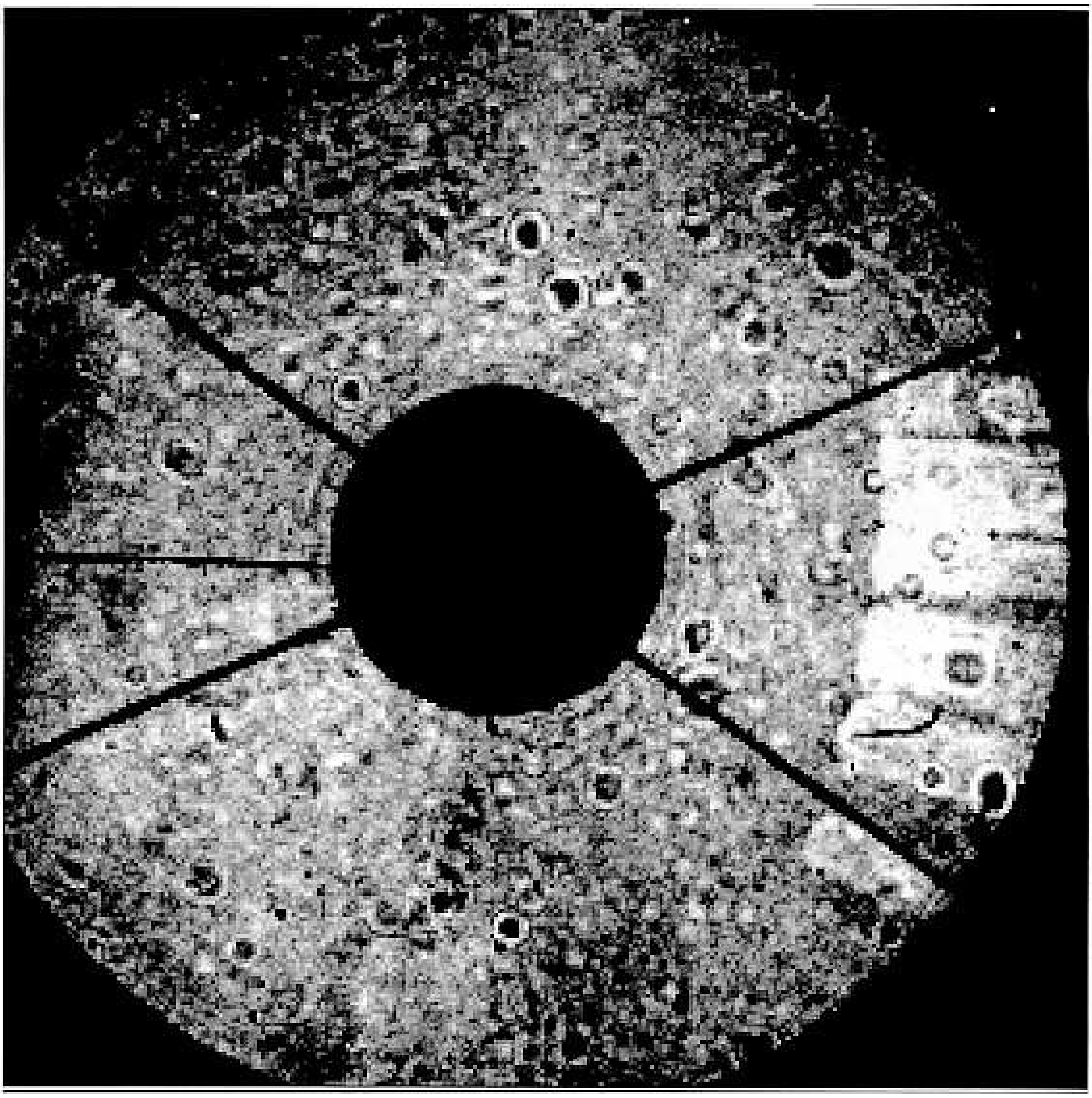

Figure 1: Reflection image of the primary mirror taken with a bright star through a pupil imaging lens in ALFOSC. The brightness indicates the reflectivity of the surface. Note that the cleaned patches on the right have increased reflectivity. From bottom to top the cleaning techniques are: dry rubbed, tomato + rubbed, tomato, HCl, HNO_3, H_2O. The darker area to the top left is the patch that was not CO_2 cleaned.

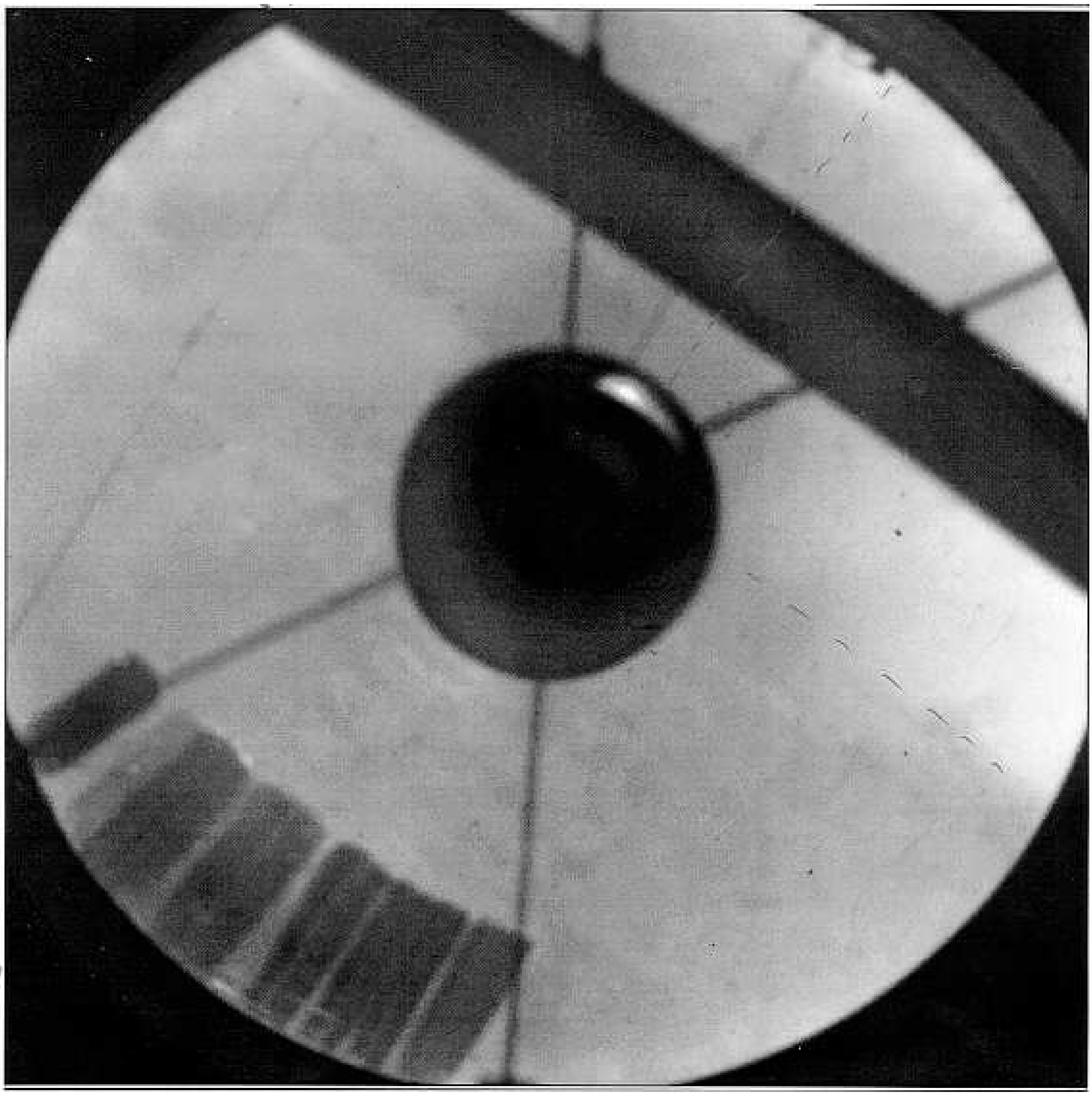

Figure 2: Image of the primary mirror taken with scattered moonlight through a pupil imaging lens in ALFOSC. The brightness indicates the scattered light from the surface. The dark bar at top right is an obstruction placed at the top ring of the telescope to block the direct light from the sky. Note that the cleaned patches on the left bottom have decreased scattered light intensity. From left to right the cleaning techniques are: dry rubbed, tomato + rubbed, tomato, HCl, HNO_3, H_2O. The bright area to the right is the patch that was not CO_2 cleaned.