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INVESTIGATION OF SL 1115 X-RAY TELESCOPE

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Joseph F. Froechtenigt

Joseph F. Froechtenigt
Space Physics Laboratory
Martin Marietta Aerospace
P.O. Box 179, Mail No. 0471
Denver, Colorado 80201

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ABSTRACT

In Phase A of this program , a polished Kanigen coated beryllium mirror to be used in a glancing incidence x-ray telescope was evaluated. X-ray photographs of the image of a standard high resolution test target were recorded at 8.34 Å and the focal plane of the telescope was determined. Reflection efficiency data was obtained using proportional counters and sources at wavelengths of 8.34, 13.3, and 44 Å. This data were compared with similar data taken with another metal mirror (previously tested under Contract NAS 8-29861). The results of the comparison were that the mirror tested in this program showed better resolution and less scattering than the other mirror previously tested. This mirror was chosen as the flight mirror for the SL 1115 X-Ray Telescope to fly on a Skylark sounding rocket.

In Phase B of this program, a position sensitive detector placed in the focal plane of the SL 1115 X-Ray Telescope (flight payload) was sucessfully calibrated using a 10 arc second point source and at wavelengths of 8.34, 13.3, 27, and 44 Å.

INTRODUCTION

This program was conducted in two phases. Phase A of this program involved the evaluation of a polished Kanigen coated beryllium mirror in a glancing incidence x-ray telescope. This mirror was polished by National Physics Laboratory in England. This telescope mirror was tested in a similar way that soft x-ray telescopes were tested previously.[1-6] This test involved inserting the telescope in a 200 foot long vacuum line and taking photographs of an x-ray resolution source. These photographs were then used to evaluate the performance of the telescope mirror as a function of distance from the focal plane. A second test was made in which a point source was used to study the imaging characteristics by means of a pinhole and proportional counter placed in the focal plane of the telescope. A comparison was made between the data obtained from this mirror with the data obtained from a previously tested metal mirror.[6] After comparison of the data, the mirror to be used on the flight payload was selected.

Phase B of this program involved using a position sensitive detector supplied by the Mullard Space Science Laboratory, University College London, England. This is the detector that will fly on the Skylark SL 1115 X-Ray Telescope mission and its performance in the flight hardware was calibrated during Phase B of this program.

PHASE A RESOLUTION STUDIES

The x-ray source used for this test was an 8.34 Å aluminum source that was essentially monochromatic with small contributions from 8 Å K_β radiation and 6.94 Å tungsten radiation. The anode voltage was 6.0 KV and the anode current was 30 ma.

The x-ray photographs taken with the Kanigen coated beryllium mirror used a twelve-wire filament configuration which produced a uniform x-ray intensity in the source.

A Buckbee-Mears JT 4.2 bar and dot resolution chart was used for all photographic data taken in this test. This chart has eleven bar sets of 5.3, 4.46. 3.75, 3.15, 2.65, 2.23, 1.88, 1.58, 1.32, 1.11, and 0.94 arc seconds angular resolution. A set of nine dots of the same angular spacing is also placed on the chart. Figure 1 is a photograph of the resolution chart.

Two types of film were used in this test. Film type SO-212 was used for data runs 140 and 141. This film was developed in Kodak D-19 at 68°F for 8 minutes, washed in distilled water for 30 seconds (to remove jet backing), stop bath was for 30 seconds, and fixed in Kodak Rapid Fixer for 2 1/2 minutes. A 30 minute rinse was followed by a photo-flow solution and the film was dried. At the start of the 30 minute rinse, it was necessary to supply light rubbing to the film to remove the jet backing not removed during the 30 second wash in distilled water. Film type SO-242 color film was used for data run 142. This film was processed by the standard Kodak E-4 process for color film.

The exposures were cut and mounted in 2-inch by 2-inch slide holders to protect the photographs. Each slide has a label

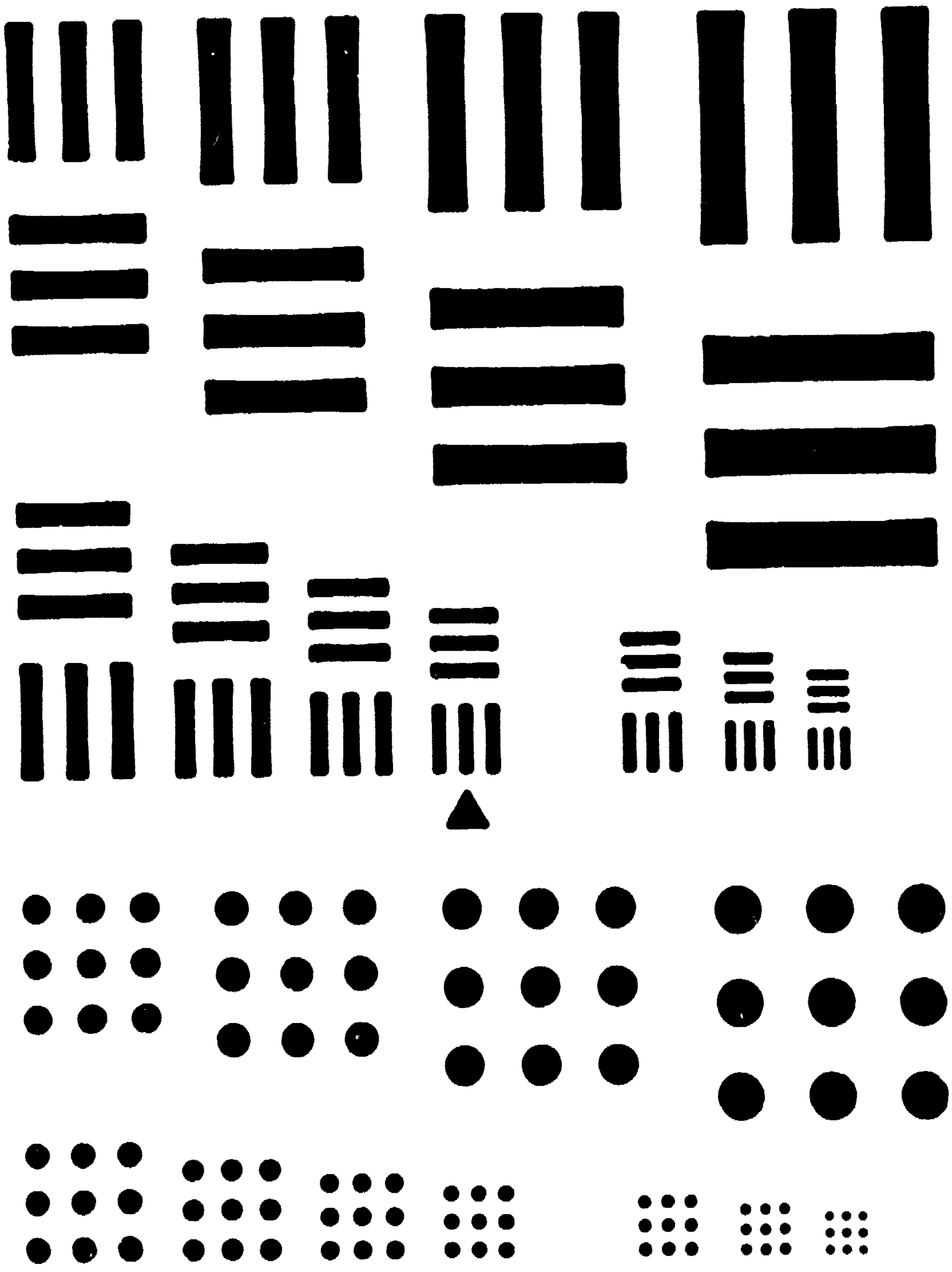

Figure 1. JT 4.2 Bar and Dot Resolution Chart

giving the run and exposure number, the wavelength, the relative distance as measured on the adjustable mechanism housing, the azimuth angle ϕ, and the elevation angle θ. When the slide is held so that the label is in the left hand corner, the photograph has the same orientation as if the observer were viewing the image in a ground glass screen attached to the telescope.

The telescope assembly (Government Furnished Property) was placed in the test chamber. The test chamber and 200-foot long line were evacuated. The pressure was reduced to approximately 1.0×10^{-5} Torr as measured by an ion gauge which was placed in close proximity to the beryllium mirror. Exposure of the resolution chart was then made using the camera which was provided with the telescope assembly.

Using the SO-212 film in this telescope, the 5.3 to 2.65 arc second vertical and horizontal bar groups could be resolved. Using the SO-242 color film in the telescope, the horizontal bar groups from 5.3 arc seconds to 1.89 arc seconds and the vertical bar groups from 5.3 arc seconds to 2.65 arc seconds could be resolved.

PHASE A POINT SOURCE TEST

A method of testing an x-ray telescope is to produce a point source of x-rays and see how well the telescope recreates the image of the source. By comparing the number of x-rays counted at the center of the image to the number of x-rays entering the telescope, the reflecting efficiency can be obtained. An indication of the scattering properties of the telescope can be obtained by measuring the x-radiation which is reflected away from the main focused beam.

The camera magazine was replaced by a proportional counter mounted on an X-Y scanner. A 6-position rotary holder was placed directly in front of the proportional counter. Three of the positions housed pinholes: a 1 mil diameter pinhole, a 3 mil diameter pinhole, and a 10 mil diameter pinhole. The other three positions were as follows: a blank position, a vertical knife edge, and a horizontal knife edge. The pinholes were placed in the focal plane of the telescope and a 10 arc second point source was examined using wavelengths of 8.34, 13.3, and 44 Å. The efficiency is computed by measuring the flux incident on the telescope, D_1 , and comparing that with the flux recorded at the pinhole in the focal plane of the telescope, D_2 . The ratio D_2/D_1 represents the intensity from a 10 arc second source that is focused on a spot corresponding to the diameter of the pinhole. Both absorption in the mirror and scattering of intensity away from the focused beam will affect the efficiency measured. Some unwanted radiation, either scattering or flourescing from the chamber, was found to be present. A stop was made that filled the diameter of the source chamber and was placed directly in front of the source holder. A 1.0 inch diameter hole in the stop allowed only the x-radiation from the point source to pass down the 200-foot line to the telescope.

Gas flow (90% argon - 10% methane) proportional counters were used to measure the incident x-ray intensity and focused x-rays through the various apertures. One counter was operated at 1400 volts and the other counter was operated at 1700 volts. The proper gain was applied to the counters so that the peak of the radiation spectrum occurred at the same position for both counters on a multi-channel analyzer. Both counters had a 0.250 inch diameter window of 1/4 mil thick mylar.

Table I gives a comparison of the reflected beam to the incident beam for the various apertures for Mirror #1 and for Mirror #2. Mirror #1 is the mirror evaluated previously.[6] Mirror #2 is the mirror evaluated in this program. These values were all taken at the point of peak intensity of the telescope.

PHASE A CONCLUSIONS

The results of Phase A of this program on a polished Kanigen coated beryllium mirror were compared with the results of a previously tested polished Kanigen coated beryllium mirror.[6] The resolution of this mirror compared to that of the previously tested mirror increased from 3.75 arc seconds to 1.89 arc seconds resolution on the Buckbee-Mears resolution chart. Examination of the photographs show less scattering for this mirror. Table I indicates the reflecting efficiency of this mirror is much greater.

The overall effect of the polishing on this Kanigen coated

Table I. Metal Mirror Comparison

Aperture mils	Mirror #1 Ratio D_2/D_1	Mirror #2 Ratio D_2/D_1
	8 Å	
1	0.122	0.262
3	0.835	1.869
10	2.962	6.115
250	15.89	16.133
	13.3 Å	
1	0.359	0.469
3	1.188	2.625
10	3.517	7.084
250	16.566	15.272
	44 Å	
1	0.198	0.439
3	0.370	3.927
10	2.670	12.230
250	11.260	23.210

beryllium mirror has made its performance better than previously tested fused silica mirrors.

The mirror evaluated during Phase A of this program was chosen as the mirror to fly on the SL 1115 X-Ray Telescope.

PHASE B CALIBRATION OF SL 1115 X-RAY TELESCOPE

The SL 1115 x-ray telescope furnished by Marshall Space Flight Center and the position sensitive detector furnished by the University College London, England were calibrated in Phase B of this program. Since the position sensitive detector used a delayed coincidence signal output, the special delay amplifiers and coincidence circuitry was built, furnished, and operated by University College London (UCL) personnel.

The position sensitive detector was placed at the focal plane of the SL 1115 x-ray telescope and the flight payload was placed in the test chamber. The test chamber and 200-foot long line were evacuated to a pressure of 5×10^{-5} Torr as measured by an ion gauge placed in close proximity to the telescope assembly. Focus tests and resolution tests were then made with the position detector.

The point source used for these tests was a 10 arc second pinhole at wavelengths of 8.34, 13.3, 27, and 44 Å.

The data obtained in Phase B of this program was taken using two UCL position sensitive detectors. This data was taken by the UCL personnel back to Mullard Space Science Laboratory so that they could analyze the data to determine the resolution of the position sensitive detector as calibrated on the flight hardware.

The GL 1115 X-Ray Telescope was sucessfully calibrated at wavelengths of 8.34, 13.3, 27, and 44 Å.

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