NASA TECH BRIEF
Goddard Space Flight Center

Measurement of X-Ray Scattering by Optical Surfaces

The problem:

The telescope, an instrument in existence for several centuries, is no longer only a visible light device. Indeed, different telescopes are being built for radio frequencies as well as for X-rays. Of the three basic designs, X-ray telescopes are the most demanding in precision. Optical surfaces built for X-ray telescopes are made to reflect very short wavelengths that range in magnitude from 2 to 100 angstroms. Minor irregularities or contamination on the surface of any telescope mirror can seriously affect the quality of an optical image at those wavelengths.

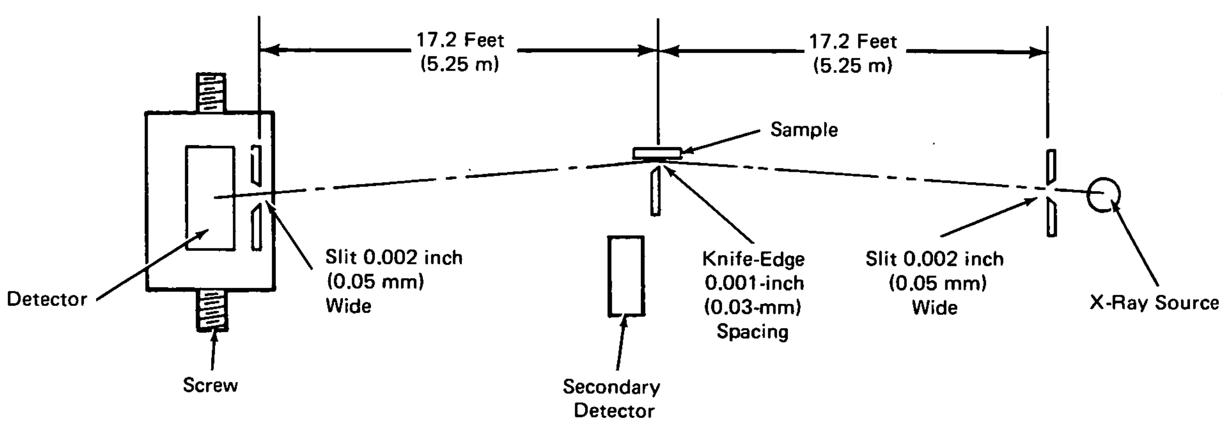
The solution:

An apparatus has been developed for checking the reflection of optical surfaces intended for the 2- to 100-angstrom soft X-ray region. Scattering of X-rays can now be measured with angular accuracy of one arc-second.

How it's done:

The apparatus uses a vacuum system consisting of three stainless-steel chambers each 24 inches (61 cm) in diameter and 12 inches (30.5 cm) high. One chamber contains an X-ray detector, the second an optical sample, and the third an X-ray source. The three chambers are interconnected by a 6-inch (15-cm), internal diameter, stainless-steel tubing which runs perpendicular to the chamber axes. The center-to-center distance between the chambers is 17.2 feet (5.25 m). The two end chambers have their own pumping systems, which produce a vacuum of 5×10^{-6} torr.

The arrangement as shown in the figure uses a demountable X-ray source consisting of a filament enclosed by a focusing cup mounted on insulators above an anode (details not shown). The X-ray source is continuously pumped and has exchangeable anodes, one of aluminum for 8.34-angstrom emission and the other of carbon for 44-angstrom emission. Accelerating voltage for the aluminum anode is 3.5 kV at 20 mA, while for the carbon anode it is 1.4 kV at 30 mA. The angle between the direction of X-ray beam and the anode is 15°. A slit 0.002 inch (0.05 mm) wide is mounted directly in front of the anode to define accurately the beam width of the source.



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The sample to be tested is mounted vertically in a holder which can be rotated in the horizontal plane in one arc-minute increments. A knife-edge spacing of 0.001 inch (0.03 mm) is provided by placing shims between the knife edge and the source.

Adjacent to the sample is a secondary detector which is used to monitor the direct beam from the X-ray source. Thus, any variation in beam intensity can be normalized by evaluating the ratio of counts in the primary and secondary detectors.

The primary detector located in the end chamber is mounted on a screw so that it can be translated across the scattered X-ray beam in 0.1 arc-second intervals. The detector is a flow-type proportional counter with a replaceable window. The window uses either the 1/4-mil (0.006-mm) aluminum for the 8.34-angstrom test or a 2-micrometer-thick Makrofol supported by a nickel mesh for the 44-angstrom test. A 0.002-inch (0.05-mm) slit is mounted directly in front of the detector window.

In use, the apparatus is aligned by means of a laser so that the angle of incidence between the sample and the source is proper. After alignment, the chambers are closed and evacuated. The X-ray source is then turned on, and the reflected beam is recorded with the detectors. Inspection of the reflected X-ray beam will then reveal the effects of imperfections on the optical surface of the sample.

Note:

Requests for further information may be directed to:

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Patent status:

NASA has decided not to apply for a patent.

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