OPTICAL ENGINEERING

STRESSED-LAP POLISHING OF LARGE, FAST ASPHERES

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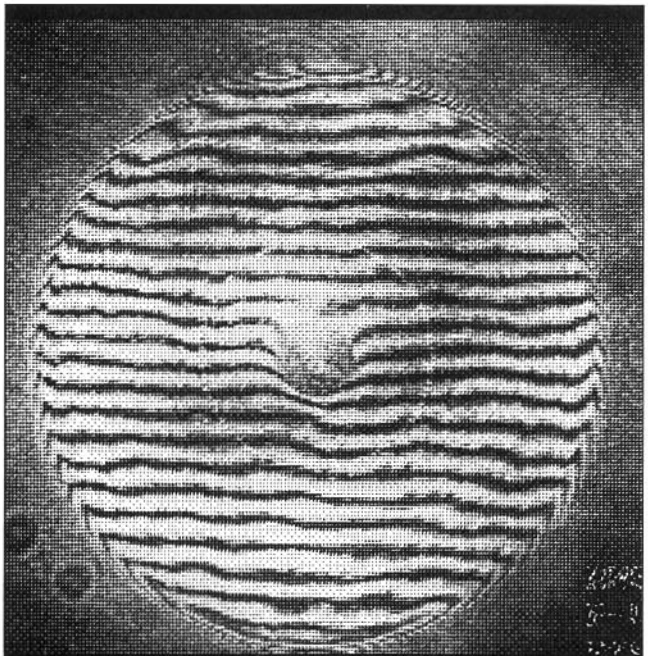
The present decade is the setting for a renaissance in the design and construction of ground-based optical and infrared telescopes. A number of projects worldwide will use primary mirrors 8 m in diameter or larger.[1] Demands of economy and performance drive these telescopes to short focal lengths. The cost of both the telescope and its enclosure increase rapidly with focal length, and the telescope's stiffness and tracking accuracy benefit from shorter length.

Several of the new telescopes will use lightweight honeycomb sandwich mirrors fabricated at the Steward Observatory Mirror Laboratory. These mirrors are spin-cast as deep paraboloids out of borosilicate glass[2] and polished using a new technique developed for these large, fast mirrors.[3,4] Three mirrors have been cast at 3.5-m diameter, and the polishing method is being demonstrated on a 1.83-m f/1.0 ellipsoid (nearly parabolic) and a 3.5-m f/1.5 paraboloid. A 6.5-m f/1.25 paraboloid will be cast during the winter of 1991-92 and subsequently polished, and 8.4-m f/1.14 primary mirrors are planned.



INTERFEROMETRIC MEASUREMENT OF THE 1.83-M F/1.0 MIRROR AT 633-NM WAVELENGTH. A TWO-ELEMENT REFRACTIVE NULL CORRECTOR COMPENSATES FOR THE 445 µM OF ASPHERICITY. THE SURFACE ACCURACY OBTAINED FROM THIS MEASUREMENT IS 34 NM RMS.

The polishing of such large, fast mirrors demands a new approach because of their extreme asphericity, with departures from the best fitting sphere as large as 1.4 mm peak-to-valley in the case of the 8.4-m f/1.14 mirrors. The mirrors are polished with an actively stressed lap, whose shape is changed continuously as it moves over the surface to match the varying curvature of the surface. This compensation for asphericity allows the use of a much larger and stiffer lap than would otherwise be possible, and hence brings in the natural smoothing action that plays a powerful role in the polishing of spheres. In fact, the goal of stressed-lap polishing is to reduce the problem of polishing a fast asphere to that of polishing a sphere with a rigid sub-diameter lap.

The stressed lap is a stiff plate faced with a polishing surface, with a diameter typically one-third that of the mirror, which is bent elastically by actuators that apply moments to the edge of the plate. These moments are varied continuously as the lap translates and rotates, causing the polishing surface to maintain accurate contact with the optical surface.

The first mirror to be polished with a stressed lap is the 1.83-m f/1.0 primary mirror for the Lennon Telescope. The polishing is proceeding, with a surface accuracy of 34 nm rms achieved as of October 1991 (see figure). The goal is an image quality of better than 1/8-arc-second full width at half-maximum, corresponding to a surface accuracy of about 25 nm rms. Stressed-lap polishing of the 3.5-m f/1.5 mirror is also proceeding and has reached a surface accuracy of 120 nm rms.

The combination of spin-casting and stressed-lap polishing holds great promise as a means of achieving apertures many times more powerful than any available to astronomers today.

REFERENCES

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