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IMPROVEMENTS OF EXISTING TELESCOPES

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I. Decrease of Shortest Wavelength

1. Improvement of Surface

First, an accurate method of measuring the surface is needed, for a large number of points, say, 10 points/panel. John Findlay of NRAO has worked out two new methods. (a) A traveling cart, pulled up along a radius, measures curvature and traveled distance. Coordinates (x, z) are then obtained by two integrations. Applied to 36-ft, with rms measuring error of 0.04 mm (Payne et al. 1974). (b) The stepping method (Findlay and Ralston, 1977) uses a rod to be moved manually along a radius by steps of its own length, measuring inclination against gravity and yielding coordinates after one integration. Was tested on one radius of 140-ft, with 0.066 mm error, yielding 0.70 mm deviations of surface from parabola.

Second, the surface can then be improved by three means. (a) Readjustment of panel corners; limited by internal bumpiness of panels (0.5 - 0.6 mm for 140-ft). (b) Design of a correcting subreflector (von Hoerner 1976a); limited if short correlation length of bumpiness gives crossing rays (as for 140-ft). (c) Resurface whole or central part of telescope; limited by funding. Very good results at Parkes 210-ft (Yabsley et al. 1977): factor 8 in shortest wavelength, factor 15 in maximum gain.

2. Best Adjustment Angle

Maximum gravitational deformations are decreased by a factor two, if telescope is not adjusted for zenith pointing but for a best zenith distance of 34° - 48° depending on two structural parameters (von Hoerner and Wong, 1975). Application to 140-ft is planned.

3. Deformable Subreflector

Gravitational deformations are mostly of a simple astigmatic shape (von Hoerner and Wong, 1975) and can be essentially omitted if a subreflector is mechanically deformed as a function of pointing elevation. A design for the 140-ft is completed, with four servo-controlled motors, to be made and installed end of 1977. The gravitational astigmatism of the 140-ft, between zenith and horizon, was measured with ΔF = 51 mm difference of focal length between two perpendicular planes (von Hoerner 1977,a).

4. Thermal Shielding

The new 7-m Bells telescope uses thermal shielding plates around the whole backup structure, and a foam spray on the backside of the panels. This may be considered also for existing telescopes, provided the internal bumpiness of the panels is small enough (not the case for the 140-ft).

5. Pointing Errors

Decrease of shortest wavelength mostly needs decrease of pointing errors, too. At the 140-ft, thermal deformations were measured with 105 arcsec peak-to-peak in polar shaft and yoke arms, between night and day from sunshine; and 50 arcsec ptp in the concrete pedestal, between winter and summer from ambient air (von Hoerner, 1976 b). Thermal shielding in 1976 has improved the pointing errors by a factor of three.

II. Noise and Efficiency

Future (minimax) telescopes should be designed, for minimum noise and maximum gain, as shaped asymmetric systems (von Hoerner, 1977 b). Some smaller improvements seem possible also for existing telescopes.

1. Spillover Collar

A simple (inaccurate) reflecting collar around the primary rim would allow slightly broader illumination (maybe 6% efficiency increase), with decreased pick-up of ground radiation (maybe by 2 °K).

2. Slant Central Mirror

Reflections from receiver box and sterling mount give standing waves and base-line wiggles, and ground radiation. A small central tilted mirror will be tried on the 140-ft by R. Fisher.

3. Guyed Legs

Support legs for the secondary have usually about 7% geometrical shadow (14% gain loss) and pick up about 6 °K ground noise by scattering. Tangential width of the legs can be decreased by use of guy cables sideways. Since 1975, the 140-ft has guyed legs, with 4.7% geometrical shadow. In addition, the scatter could be reduced by flat spoiler plates inside the legs, directing the scatter to primary and sky. Total improvement maybe 5% for gain and 3 °K for noise.

4. Third Reflector

For an existing parabolic (or spherical) main reflector, two shaped subreflectors can be designed to transform a narrow feed pattern into a uniform aperture illumination. Improvement probably 15% for gain and 3 °K for noise. Limited to large primaries or short wavelengths, since both subreflectors must be many wavelengths large ($\geq 40\,\lambda$, say).

References

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