Evidence of Limb-brightening of the Sun at 60 cm Wavelength*

The figure in the paper shows the measurements made using the 32 element interferometer. These elements were parabolic dishes, each about 1.68 m in diameter. This leads to a beam size of about 25° at the wavelength of 60 cm. They were placed in an equispaced manner along the East-West (E-W) direction, spanning a distance of about 21 m (700 ft). The details of the system, designed to provide high-resolution observations of the Sun albeit it only along one direction (E-W), originally worked at a wavelength of 21 cm are described in Christiansen and Warburton (1955, *AuJPh*, 6, 190). Combining the signal from these elements, gave rise to what is referred to as a fan-shaped beam along the E-W direction—an equispaced series of high-resolution beams (8.25 arcmin in the present case) separated by angular distances of about 5°. The envelope of this family of beams is defined by the beam (directivity pattern) of individual elements of the interferometer. The separation between the adjacent beams was designed to be much larger than the angular size of the Sun, so the Sun would be seen only in one of the beams at any time.

The measurements obtained thus represent a convolution of one of the 'fans' of the fan beam, narrow along E-W and as broad as the beam of the individual elements along the N-S direction. In order to figure out if there was indeed limb brightening on the Sun, Swarup and Parthasarthy (1955) needed to remove or deconvolve the smoothing effects of the beam. The radial brightness distribution so obtained is shown in *Figure* 6 of a more detailed publication on the subject by Swarup and Parthasarthy (1955, *AuJPh*, 8, 487). As evident from this figure, the reconstructed one-dimensional brightness distribution does indeed show significant limb brightening. The figure also shows an earlier result by Stanier (1950), which did not show limb brightening. The discrepancy between the two is much larger than the uncertainty on the measurements by Swarup and Parthasarthy (1955).

The Sun was one of the few radio sources known then and a very enigmatic one—the million K corona had been discovered in the 1940s, and a bewildering variety of emissions spanning a large range in intensity and their appearance in the frequency-time plane in the early 1950s. Considerable effort was being expended on understanding the Sun on the theoretical front. This work was a very innovative use of the available technology for an unprecedentedly detailed exploration of the Sun. This work firmly established solar limb brightening at decimeter wavelengths, consistent both with theoretical expectations and earlier observations at higher frequencies. The earlier attempts at these frequencies had either remained inconclusive or gave contrary results primarily due to difficulties of isolating the 'quiet' component of solar emission. On the techniques front, this work sowed the seeds of the round-trip phase path measurement scheme which Govind pioneered and is now in use at every major radio interferometer in the world.

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EVIDENCE OF LIMB-BRIGHTENING OF THE SUN AT 60 CM WAVELENGTH

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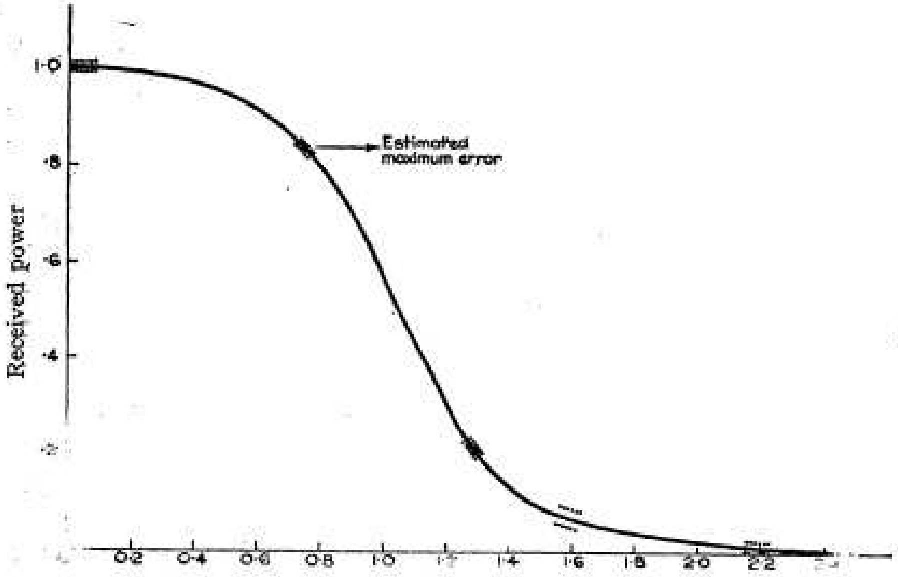
Theoretical calculations of the brightness distribution over the "quiet" Sun at wavelengths in the vicinity of 60 cm predicted the presence of limb-brightening for a wide range of assumed conditions.[1] However, on



Distance from centre of disk (units of R_0)
One-dimensional brightness distribution at 60 cm.

the basis of observations made with a two-aerial interferometer at a wavelength of 60 cm, Stanier[2] derived a distribution in which limb-brightening was absent. This unexpected result has prompted us to employ an independent technique to make observations of the brightness distribution at the same wavelength. We used the 32-element interferometer described by Christiansen and Warburton[3] which, at a wavelength of 60 cm, gives fan-shaped beams of half-power width 8′·25 in an E–W direction. The beam has adequate directional discrimination to distinguish between the localized bright areas and the thermal emission from the "quiet" Sun.

The variable components of radiation have been eliminated by superimposing a number of daily observed records for 1954 July. The direction of scanning at this time was along the equator of the Sun, and the lower envelope of the recorded patterns may be taken as the one-dimensional scan of the "quiet" Sun in this direction. The lower envelope, which within experimental errors was found to be symmetrical about the centre, is shown in the accompanying figure.

Although recent observations at other wavelengths have indicated that the brightness distribution over the solar disk is non-circular, we have, for the purpose of comparing our observations with those of Stanier, assumed circular symmetry. The radial brightness distribution so derived from the present observations shows marked limb-brightening, whereas Stanier's result showed limb-darkening. After the smoothing effect of the aerial beam has been partly removed, the intensity at the limb is about 50 per cent higher than that near the centre.

Stanier's observations were made near the maximum phase of the solar cycle, while the present observations have been made during the current minimum phase. The discrepancy between the two results could be due either to an actual change in the "quiet" Sun or to errors in Stanier's result, caused by the presence of unrecognized bright areas. Stanier has not given details of the method he used to allow for such bright areas, and without further information it is not possible to decide which alternative is the more likely.

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