POLAR-CAP AND CORONAL-HOLE-ASSOCIATED BRIGHTENINGS OF THE SUN AT MILLIMETER WAVELENGTHS

(Extended Abstract)*

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Mapping observations of the Sun at millimeter wavelengths were made on 16 to 22 July 1984 with the 45-m telescope of the Nobeyama Radio Observatory. Seven 36-GHz (8.3-mm) maps and five 98-GHz (3.1-mm) maps were taken with half-power beam widths of 46″ and 17″, respectively.

Instead of the conventional rastering technique, we adopted a radial-scan method in which every scan passes through the disk center. Accordingly, the variation of the atmosphere attenuation due to changes in the weather conditions can be easily estimated and removed by using the brightness values at the disk center as calibration data. Also, the pointing errors of the telescope due to the high-speed scans can be corrected by using the solar limbs as position references. The rms residual errors in relative brightness and position after the corrections were estimated to be ~2% and ~5″, respectively. To further reduce these errors, a smoothing technique was applied in making the two-dimensional maps. Thus, the radial-scan method, together with the beam of the telescope with a small error pattern, enabled us to make high-quality maps with $\lesssim$1% uncertainty in brightness. Here and in the following, brightness is expressed in terms of the average brightness of the solar disk as a unit. Note that the brightness temperature of the quiet Sun is ~8000 K and ~6000 K at 36 GHz and 98 GHz, respectively (e.g., see a review by Furst, 1980).

We perceived on the maps many local brightness enhancements and depressions, most of which are correlated well with active regions and optical filaments (e.g., Furst et al., 1973). However, we found that on the 36-GHz maps there are two types of brightness enhancements which are not associated with active regions.

One is what we call polar-cap brightnening (cf., Babin et al., 1976; Efanov et al., 1980a,b). It was an extended region around the poles with a brightness excess of ~5%. It can be seen in both polar regions in all the maps taken at 36 GHz between 16 and 22 July 1984. The boundary of the polar-cap brightenings was located at a latitude of ~65 deg in both hemispheres, which was very close to the boundary of the polar coronal holes observed in the 10830 Å helium line in this period. There is no doubt that the polar-cap brightening is a pole-related phenomenon but not a so-called limb brightening, because the apparent north-south asymmetry between two polar-cap brightenings is well explained by the orientation of the poles

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with respect to the line of sight, and also because no limb brightenings above 1% are observed in the equatorial region on the same maps.

The other type of brightness enhancement is found in one equatorial coronal hole region (cf., Papagiannis and Baker, 1982). Again the brightness excess was ~5%. However, the bright region occupied only half the area of the coronal hole region. Moreover, another equatorial coronal hole region was not associated with millimeter-wave brightenings, though two small areas in this region appeared to be slightly brighter than the surroundings. From the comparisons with optical and other observations, it seems that the presence of white-light faculae and/or an intense magnetic field are essential for the brightening to occur in a coronal hole region.

No corresponding brightenings are found at 98 GHz for either type of 36-GHz enhancements.

It is suggested that the two types of brightenings at 36 GHz are two aspects of one phenomenon, associated with polar and equatorial coronal holes, and that the temperature and density structure of the upper chromosphere in coronal holes differs from that outside holes.

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