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Solar microwave scintillation

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With the sun as a source, scintillations at four microwave frequencies were observed for 1 year. Scintillation was a daily occurrence at sunrise at elevation angles from 1.5° to 7°. This observation indicates the continued presence of point sources on the sun during the peak of the sunspot cycle. It also suggests that the peculiar terrain configuration along the propagation path is conducive to the production of irregularities in the troposphere. Scintillation data can provide information about the troposphere and about the spectrum of the slowly varying component of solar emission.

INTRODUCTION

There is great interest today in the increased use of microwave frequencies for communication between earth stations and between earth stations and space vehicles. Thus it is important to understand fully the effects of the atmosphere on the propagation of microwave energy. One effect is rapid signal fluctuation, or amplitude scintillation. In this paper we review a year's data (1967–1969) of microwave scintillation observed at Manilla (14.6°N, 121.1°E). The sun is the microwave source, and the detector is a radio telescope consisting of an 8-foot parabolic reflector with a multifrequency feed. The operating frequencies are 8800, 4995, 2695, and 1415 MHz, which are referred to hereafter as *X, C, S,* and *L* bands, respectively. This is a good example of the use of radio astronomy to learn more about the earth's environment.

OBSERVATIONS

Microwave scintillation is observed to be essentially a phenomenon of low elevation angle. Figure 1 shows scintillation on all four frequencies at sunrise. Astronomical sunrise is at an elevation angle of 0°, but at our location the sun cannot be seen at elevation angles of less than 1.5° because of a north–south mountain range due east of the antenna site. The dashed line is the background signal, which is made up of sky and ground radiation. Scintillation decreases with elevation angle, becoming negligible at 8° and greater. For this particular sunrise at about 2° elevation, the scintillation index (defined below) is 0.20 at *X* band, 0.40 at *C* band, 0.45 at *S* band, and 0.20 at *L* band, although there are time intervals also at 3° and 4° during which the scintillation index is high.

To determine the amount of scintillation, the concept of a scintillation index is used. The scintillation index is the ratio formed by the deviation from the mean intensity divided by the mean intensity. In practice the scintillation index (SI) is calculated by the relation

$$\mathrm{SI} = (\max - \min)/(\max + \min) \qquad (1)$$

where max is the highest crest and min is the lowest trough (after the sky and ground contributions have been subtracted) in a given time interval. Signal fade is related to the scintillation index as follows:

$$\text{signal fade (db)} = 10 \log (1.0 - \mathrm{SI}) \qquad (2)$$

Thus if SI is 0.30, the signal fade is 1.5 db.

The SI of solar signals varies with frequency in an undetermined manner. On some days it is higher in the upper frequencies, and is otherwise on still other days. The problem with solar scintillations (as contrasted with those from radio sources such as Cygnus, for example) is that star sources are point sources with constant spectra, and all variations of scintillation with elevation angle from day to day are related to atmospheric effects. These variations prevail from the sun also, but the enhancements from one or several solar point sources also contribute and constantly change. Table 1 shows the month-to-month variation of the SI at 2° elevation