SPECTRAL DISTRIBUTIONS OF MICROWAVE BURSTS

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Abstract. The lack of open literature publication of the distributional properties of the cm-λ spectra of solar microwave bursts has lead to some erroneous concepts of the typical characteristics of these spectra. To provide more accurate information, this paper sets forth various distributions of the peak flux density spectra of large numbers of bursts, based on observations of the Sagamore Hill Radio Observatory at nine discrete frequencies between 245 and 35000 MHz over the years 1968–1971. As a foundation for the distribution studies, the basic spectral classification system is outlined. The majority of burst spectra were found to contain a cm-λ component having a single spectral maximum in the 1400 to 35000 MHz range; such spectra are designated C type. A study of the correlation of the spectral maximum frequency $f_{\text{max}}$ of the cm component and the photospheric magnetic field strength of the associated region shows a tendency for greater correlation at higher $f_{\text{max}}$ for stronger magnetic fields. A study of the correlation for C type spectra between $f_{\text{max}}$ and the quasi-cutoff frequency $f_qe$ on the low-frequency side shows that for bursts of moderate peak flux density (50–500 sfu) $f_qe$ is well correlated with $f_{\text{max}}$; a good fit to the relation $f_{\text{max}} = A f_qe$ is found with $A = 3.4$. The possible attenuating mechanisms responsible for the spectral shaping of the cm component are discussed.

1. Introduction

Unlike meter-λ solar radiation, where morphological considerations (classical types I to V) predominate, AFCRL's investigation of cm-λ burst radiation emphasizes spectral studies. These include both the study of the time-varying spectrum during large bursts and the statistical study of the peak spectra of large numbers of mostly small bursts (presented here). The purpose of these studies is to determine emission mechanisms and burst region parameters such as magnetic field strength, electron density and electron energy distribution.

Many geophysicists and those concerned with optical, X-ray, or particle emission from the Sun seem to think that the 2800 MHz (10 cm) patrol gives the only important cm-λ data needed. Yet this frequency region may be one of the least significant; for the large proton-producing bursts, intensity is often minimal around 2800 MHz. What is important in the study of flare-bursts and solar-terrestrial activity is that there are differences in the radio spectral characteristics over the dm-cm range. This paper, using a previously defined classification system, presents some of the distributional properties of the peak flux density spectra of large numbers (~2400) of bursts observed over the 1968–1971 period. The data base is the well-calibrated sunrise-to-sunset records of the 245, 410, 606, 1415, 2695, 4995, 8800, 15400, and 35000 MHz patrols of the Sagamore Hill Radio Observatory (Castelli et al., 1973).

2. Spectral Distribution

To investigate distributions, a basic classification scheme, discussed in previous papers
(Castelli and Guidice, 1972), is illustrated in Figure 1. The three basic types of spectra are: G type, flux density increasing with decreasing frequency; C type, flux density reaching a single spectral maximum in the cm range and decreasing on both sides of this maximum; and A type, flux density increasing with increasing frequency. Burst intensity is divided into three levels: Intensity 1, peak flux density reaches a value of less than 50 solar flux units (sfu = $10^{-22}$ W m$^{-2}$ Hz$^{-1}$); Intensity 2, peak flux density reaches a value between 50 and 500 sfu; Intensity 3, peak flux density reaches a value greater than 500 sfu at any of the patrol frequencies.

Fig. 1. Idealized drawing of the principal spectral types and intensity sub-groupings.

For C type spectra we have an additional classification category, the band in which the burst reaches its spectral maximum. For cm wavelengths, the patrol frequencies are associated with certain radar bands: 1415 MHz with L-band, 2695 MHz with S-band, 4995 MHz with C-band, 8800 MHz with X-band, 15400 MHz with K-band. When we say the spectral maximum occurs in one of these bands, it is the band corresponding to the patrol frequency at which the largest peak flux density value was measured, even though the actual spectral maximum obviously does not occur precisely at any patrol frequency.

Besides the basic spectral types (G, C, and A), there is another kind of cm-range spectrum related to the C type which we call miscellaneous or M type. It has more