Scintillation of Solar Radio Sources: Implications for Spikes

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Some results of a theoretical analysis of the intensity fluctuations due to the scattering in the solar corona of the emission of a reasonably compact radio source are presented. The intensity fluctuation spectrum is closely related to the angular spectrum of scattered emission. Therefore, experimental verification of some outcomes of such an analysis could also serve as a test of the idea itself of the substantial influence of the scattering of the emission upon the observed angular size of solar microwave sources (T.S. Bastian, 1994, Astrophys. J., 426, 774). Since spike burst sources are candidates for the role played by very compact objects, pertinent attention is given to these events.

The properties of intensity fluctuations in extended medium with a power spectrum of fluctuations of the refractive index depends virtually on a single parameter. In the case of a plane wave and statistically homogeneous media this parameter is represented by the value of a structure function of complex-phase fluctuations calculated on the size of the first Fresnel zone. In the real solar corona and spherical wave case of concern to us the notion of this parameter should be corrected.

a) The regime of strong scattering, in which scintillations go saturated, is a candidate for a typical regime of solar decimetric and even centimetric emission. For a coherent (point) source, this signifies an approximate equality of the fluctuation dispersion and the mean value of the intensity.

b) Since the emission source co-rotates with the Sun, the corresponding diffraction pattern sweeps past the terrestrial observer with a velocity of about 400 km s^{-1}. This is the governing

factor in the transition from a spatial to temporal spectrum of intensity fluctuations. And the same factor becomes decisive when explaining the large angular size of spike burst sources recorded at the Siberian Solar Radio Telescope (SSRT).

c) With the SSRT time resolution $\simeq$ 14 ms, the long-exposure mode when it is impossible to identify the specle-image of the presumed, nearly point source, corresponds to the observation of spike bursts, the apparent size of which exceeds $10''$. This reasoning draws on a wide-spread belief that the main characteristics (a very short duration, the narrow-banded character, and a reasonably high intensity) of the spike bursts, are caused entirely by physical processes occurring in a small (by volume) impulsive emission source. It is likely that such is indeed the case on many occasions. But if there exists the scattering of the emission leaving such a source which leads to an appreciable growth in the angular size, then the influence of the propagation medium upon the temporal profile and the frequency spectrum of observed spike bursts can become important.

d) Moreover, spike bursts can also be associated with spatial spikes of a random intensity field of a sufficiently bright, compact (but not "operating" in the impulsive mode), broad-banded solar radio source. Since the intensity spike is caused by a random focusing of the emission by large-scale inhomogeneities, the angular size of the observed spike burst must correspond to the aperture (up to $10''$) of the focusing "lens". Temporal characteristics of such (formed by the propagation medium) intensity spikes may correspond to observed spike bursts. Spike bursts that have formed in such a fashion, must also be narrow-banded. The only limitation in this case is on the true size of the radio source – not larger than a few tens of kilometers in the case of strong spikes if the observation wavelength is 5 cm. If the true size of the radio source is large, it is

still possible to detect the low-frequency (a few seconds or longer) envelope of fast intensity variations.

e) It may be anticipated that the weak scattering regime is possible at short wavelengths (perhaps at about 1 cm or shorter). The exact and approximate solutions for the spectrum of temporal intensity fluctuations in this regime are given. The frequency, at which the spectrum shows a bend, is determined by the location of the effective scattering screen if the source size is not too large.