CUTOFF FREQUENCY OF ITKR / LOW-FREQUENCY BURSTS IN THE SOLAR WIND

Jean-Louis Steinberg[(1)], Philippe Zarka[(2)], Catherine Lacombe[(3)], Sang Hoang[(4)]

[(1)]Observatoire de Paris - CNRS, LESIA, Place J. Janssen, 92195, Meudon, France,
E-mail: jean-louis.steinberg@obspm.fr

[(2)]As (1) above, but, E-mail:philippe.zarka@obspm.fr

[(3)]As (1) above, but, E-mail:catherine.lacombe@obspm.fr

[(4)]As (1) above, but, E-mail:sang.hoang@obspm.fr

ABSTRACT

From a study of ≥100 Low-Frequency (LF) bursts recorded by the WIND/Waves experiment in the solar wind, we attribute their low-frequency cutoff to a combination of three phenomena: (1) an occultation by the density jump along the flanks of the Earth's bow shock, upstream of the point where the lowest LF burst frequencies escape from the magnetosheath ; (2) a possible occultation by solar wind density bumps that may intervene between the shock flank and the spacecraft ; (3) strong angular scattering of the radio waves at frequencies slightly above fp_{sw} by solar wind density fluctuations.

INTRODUCTION

LF bursts are observed from the L1 point [1] and on the morning flank of the Earth's magnetosphere [2]. They are detected down to frequencies as low as the solar wind plasma frequency (fp_{sw}). At such low frequencies, the angular diffusion by density fluctuations is high enough to make the source appear isotropic, with a dynamic spectrum similar to that of an interplanetary type III burst. This isotropic part of the LF burst is prominent and has a characteristic shape, so that it was discovered first and named isotropic terrestrial kilometric radiation (or ITKR) [3,4]. Seen from the morning side, below $2\times fp_{sw}$, ITKR is preceded by a brief directive (non-isotropic) spike [2], which seems to exit the Earth's bow shock between -100 and -400 Earth radii (R_E) downstream (for $1.2\times fp_{sw} \leq f \leq 1.4\times fp_{sw}$). For the specific case of an LF burst partly occulted by a density bump in the solar wind, [5] confirmed that its lowest frequencies cannot escape from the shock less than -100 R_E downstream of the Earth's position. Reference [6] also showed that the time profile of an ITKR event propagating from the Earth to L1 through the magnetosheath and the solar wind implies a tailwards propagation velocity in the magnetosheath lower than the local group velocity ($c\mu$, with μ the refraction index). Reference [5] also mentioned that the LF burst highest frequencies ($\geq 2\times fp_{sw}$) can exit the shock close to the nose of the magnetosphere, while the lowest frequencies ($\leq 2\times fp_{sw}$) can only exit the flanks.

PROBLEM

For more than 100 Low-Frequency (LF) bursts recorded by the WIND/Waves experiment in the solar wind, we have studied the lowest frequency at which the ITKR part of the LF burst is observed. The ratio fc/fp_{sw} of this cutoff frequency fc over the local solar wind plasma frequency fp_{sw} ranges between 1.01 and 2, with an average value of 1.3. Such a cutoff may be attributed to a combination of three phenomena: (1) an occultation by the density jump along the flanks of the Earth's bow shock, upstream of the point where the lowest LF burst frequencies escape from the magnetosheath ; (2) a possible occultation by solar wind density bumps that may intervene between the shock flank and the spacecraft ; (3) strong angular scattering of the radio waves at frequencies slightly above fp_{sw} by solar wind density fluctuations.

RESULTS

We show that all these three phenomena probably intervene. (1) and (2) are studied using a geometrical model of the Earth's bow shock consistent with our measurements of fc as well as with the observations of the solar wind conditions during the 12 hours preceding each LF burst studied. (3) is addressed through a simple model of radio waves scattering in a homogeneous medium, that allows us to evaluate the isotropisation and eventual cutoff of the radiation as a function of distance to the source and of the fc/fp_{sw} ratio.

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