Obliquely propagating waves in bi-kappa plasmas

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The effects of velocity distribution functions (VDFs) that exhibit a power-law dependence on the high-energy tail have been the subject of intense research by the space plasma community. Such functions, known as kappa (or superthermal) distributions, have been found to provide a better fitting to the VDFs measured by several spacecraft in the solar wind, in contrast to models that employ combinations of Maxwellian VDFs. Among the relevant problems pertinent to the physics of the solar wind, one can mention the origin of the temperature anisotropy displayed by both the protonic and electronic VDFs. The existence of these nonthermal characteristics implies that the particles contain a large amount of free energy that can be used to excite waves present in the thermal radiation background. Conversely, the wave-particle interaction is important to determine the shape of the observed distributions. The majority of studies concerning wave-particle interactions in the solar wind were carried out employing Maxwellian distributions. It is just recently that kappa VDFs have been considered. In the literature, the general treatment for waves excited by bi-Maxwellian plasmas is well-established. However, for kappa distributions (isotropic or anisotropic), the wave characteristics have been studied mostly for the limiting cases of purely parallel or perpendicular propagations. The general case of obliquely propagating waves have been scarcely reported so far. The absence of a general treatment prevents a complete analysis of the wave-particle interaction in superthermal plasmas. This situation is being remedied by a series of papers published by the authors. In a first work (Gaelzer & Ziebell, 2014), we have obtained expressions for the dielectric tensor components and subsequent dispersion relations for the dispersive Alfvén waves resulting from a kappa VDF. Subsequently, Gaelzer & Ziebell (2016) extended the initial formalism for the general case of electrostatic and/or electromagnetic waves propagating in an isotropic kappa plasma in any frequency range and for arbitrary angles. In the present work (Gaelzer et al., 2016), we generalize even further the formalism by the derivation of the general dielectric tensor for an anisotropic bi-kappa plasma. We present the formalism and show how it enables a systematic study of electromagnetic/electrostatic waves propagating in arbitrary directions and polarization and in any frequency range in a bi-kappa plasma.

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