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Towards a realistic prediction of the solar wind plasma microinstabilities

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Two scenarios are known for the origin of the field and density fluctuations observed in the solar wind. Thus, the fluctuations can be induced at different scales, either locally and self-consistently by the kinetic anisotropy of plasma particles, or can be injected at larger scales closer to the Sun and then decayed and transported by the super-Alfvénic wind. In both scenarios, details of the plasma microstates - the particle velocity distributions (VDFs), are needed for an accurate description of the fluctuations. In-situ measurements reveal nonequilibrium plasmas with VDFs comprising two major components, a Maxwellian (thermal) core and a less dense but hotter suprathermal halo with a power-law distribution best described by the Kappa models, and the field-aligned strahl as a third component, usually assimilated with the suprathermal populations. Despite this observational evidence, the existing attempts to parameterize the observed (anisotropic) distributions and the supporting fluctuations and instabilities are limited to simplified models, which either ignore the suprathermal halo or just minimize the role of the core assuming it cold, or artificially incorporates both the core and halo in a single, global Kappa that is nearly Maxwellian at low speeds and decreases smoothly as a power law at high speeds. Simplified models imply a reduced number of plasma parameters and are convenient computationally, but they omit important kinetic effects of the plasma particles. Realistic models imply a large number of parameters, especially in the presence of kinetic anisotropies, and make it difficult to identify the instability conditions. However, in a recent endeavor to investigate nonindealized situations when both the core and halo temperatures are finite and anisotropic, we found computationally tractable such a complex model that combines an anisotropic bi-Maxwellian core and an anisotropic bi-Kappa halo. This model is relevant for the slow wind conditions and, in general in the solar wind at large heliocentric distances, e.g., $>$ 1 AU, when the field-aligned strahl is significantly diminished. Here we present our first results for the particular case of the EM cyclotron instabilities driven by the electron temperature anisotropy, and provide a contrasting picture with the idealized models. Perspectives are also discussed to apply the same model and stability/dispersion analysis for a realistic characterization of the complementary instabilities, e.g., firehose, mirror, etc., of interest in space plasma physics.