Role of microinstabilities in expanding solar wind: Quasilinear Approach (bold, 14 pt)

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In situ measurements for the solar wind unveiled the accumulation of large amount of data near the marginal stable states. Microinstabilities driven either by temperature anisotropy or by relative drift between plasma components. To explain these handsome amount of observed data with instabilities, we developed a quasilinear (QL) theory particularly for such weak growth approximation. For the validation of our QL theory results, we then compare them with particle in cell simulation and with observations. We present QL theory and Particle-in-cell simulation (PIC) of electromagnetic electron cyclotron (EMEC), proton cyclotron and ion/electron mirror instabilities for the solar wind plasma. We make choice of initial parameters which support the simultaneously excitation of combined wave-format for unstable modes. Based on velocity-moments, we employ weak-growth rate formalism to investigate the wave dynamics that contrasts to our earlier efforts which relied on the transcendental plasma dispersion function method. A bi-Maxwellian form of the electron and proton velocity distribution function (VDF) is adopted in which temperatures of species may evolve in time. Our approximations regarding the choice and shape of the distribution are already well established through comparative QL analyses and different particle-in-cell (PIC) simulation works. Upon comparing the QL calculation with PIC simulation results and solar wind observations, we found an appreciable agreements of time varying quantities and trajectories of charged species in phase space. In spite of these agreements, we also find a discrepancy with the existing similar work and point to the need for further investigation regarding possible reasons for such a difference.

We note that analytical formulation greatly simplifies the numerical effort, and it will aid in the solar wind modeling effort in which various effects such as the non-thermal populations, radial expansion, collisions, and wave-particle interactions can be combined in order to more accurately assess the dynamical progression of the solar wind. Our present research work will be an important step in this regard.