Kelvin–Helmholtz instability of magnetohydrodynamic waves travelling along a coronal mass ejecta in the lower corona

I. Zhelyazkov

Faculty of Physics, Sofia University, 1164 Sofia, Bulgaria

In a recent paper, Foullon et al. [1] have reported that on using the new capabilities for studying the Sun they succeeded to image for the first time the magnetic Kelvin–Helmholtz (KH) instability developing at the surface of a fast coronal mass ejecta (CME) less than 150 Mm above the solar surface. They conducted a detailed observational investigations of this phenomenon, observed off the east solar limb on 2010 November 3, in EUV with SDO/AIA. In conjunction with STEREO-B/EUVI, the authors derived the CME source surface position. By evaluating and validating the consistency of the observations with theoretical considerations and predictions, they took the view that the ejecta layer corresponds to a reconnection outflow layer surrounding the erupting flux rope, accounting for the high temperature (∼11.6 MK) and high flow shear (∼680 km s⁻¹) on the unstable northern flank and for the observed asymmetry between the CME flanks.

Here, we offer a theoretical modelling of the KH instability detected by Foullon et al. [1] considering the coronal mass ejecta as a high-temperature and high-speed cylindrical jet of radius a contained in a twisted magnetic field surrounded by a cooler plasma immersed in an untwisted magnetic field of 10 G. We study the propagation of magnetohydrodynamic (MHD) waves with mode numbers \( m = 1, 2, \) and 3 on using a dispersion relation derived from the basic equations of ideal compressible magnetized plasmas. The density contrast between the jet (label ‘i’) and its environment (label ‘e’), \( \rho_e / \rho_i \), is taken to be equal to 0.88, while the sound and Alfvén speeds in both media are \( c_{si} = 563 \) km s⁻¹, \( v_{Ai} = 503 \) km s⁻¹, and \( c_{se} \approx 290 \) km s⁻¹, \( v_{Ae} \approx 790 \) km s⁻¹. The numerical solving the complex wave dispersion relation shows that the \( m = -2 \) and \( m = -3 \) MHD modes become unstable in narrow instability windows on the \( k_z a \)-axis depending on the magnetic twist parameter \( \varepsilon = B_{i\phi} / B_{iz} \). The critical Alfvén Mach numbers obtained for \( \varepsilon = 0.025, 0.1, \) and 0.2, are correspondingly equal to 1.35, 1.3, and 1.25 which yield threshold jet’s speeds of 679 km s⁻¹, 654 km s⁻¹, and 629 km s⁻¹ in a very good agreement with the speed for occurrence of the KH instability detected by Foullon et al. [1].

References