On Magnetohydrodynamics, Fluctuations, Structures, and Turbulence

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Small amplitude fluctuations in the magnetized solar wind are measured typically by a single spacecraft at a particular Doppler-shifted frequency or set of frequencies and a corresponding wave number vector **k** can be inferred using various techniques. In the magnetohydrodynamics (MHD) description, fluctuations are typically expressed in terms of the wave modes admitted by the system. An important question is how to resolve an observed set of fluctuations, typically plasma moments such as the density, velocity, pressure and magnetic field fluctuations, into their constituent fundamental MHD modal components. Surprisingly, this problem has not yet been fully resolved despite its importance in understanding the most basic elements of waves and turbulence in the solar wind. For example, a decades long argument has persisted about whether turbulence in the solar wind is Alfvenic (i.e., dominated by Alfven waves) or dominated instead by magnetic structures (i.e., dominated by flux ropes, aka magnetic islands). Unfortunately, a method was not hitherto developed that identifies between wave modes and advected structures such as magnetic islands or entropy modes. Here, we discuss quite generally the identification of wave modes in an MHD plasma from a set of plasma and magnetic field fluctuations measured by a single spacecraft at a specific frequency and an inferred wave number. We present data from a typical interval measured by the WIND spacecraft and show how the new method allows for the identification of both propagating (wave) and non-propagating (structures) modes, including entropy and magnetic island modes. This allows us to derive separate wave number spectra of entropic density, fast and slow magnetosonic, Alfvenic, and magnetic island fluctuations for the first time. The importance of these results in identifying the fundamental building blocks of turbulence in the magnetized solar wind will be discussed.

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