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A Nearly Incompressible Description of Low-Frequency Turbulence in the Solar Wind

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The theory of nearly incompressible magnetohydrodynamics (NI NHD) was developed largely in the early 1990's together with an important extension to inhomogeneous flows in 2010. Much of the focus in the earlier work was to understand the apparent incompressibility of the solar wind and other plasma environments, and the relationship of density fluctuations to apparently incompressible manifestations of turbulence in the solar wind and interstellar medium. Further important predictions about the "dimensionality" of solar wind turbulence and its relationship to the plasma beta were made and subsequently confirmed observationally. However, despite the initial success of NI MHD in describing fluctuations in the solar wind, a detailed application to solar wind turbulence has not been undertaken. Here, we use the equations of NI MHD to describe solar wind turbulence, rewriting the system in terms of Elsasser variables. Distinct descriptions of 2D and slab turbulence emerge naturally from the Elsasser formulation of NI MHD, as do the nonlinear couplings between 2D and slab components. For plasma beta order 1 or less regions, distinct predictions for 2D and slab spectra result from the NI MHD description, and predictions for the spectral characteristics of density fluctuations can be made. A preliminary comparison of theory and observations is presented. We conclude by presenting a NI formulation describing the transport of turbulence throughout the solar wind, including low plasma beta environments such as the solar corona.