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Multiple-scale analysis of turbulent transport in strongly compressible magnetohydrodynamic flows

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A system of equations of fully compressible magnetohydrodynamic (MHD) turbulence is analyzed with the aid of an elaborated closure scheme for fully developed turbulence coupled with a multiple-scale analysis. In the formulation, all the effects of anisotropy and inhomogeneity associated with rotation, density stratification, magnetic field, etc. are incorporated in a perturbative manner through the derivative expansion with respect to the large-scale inhomogeneity in time and space. Expressions of the relevant turbulence correlations, such as the turbulent mass flux $\langle \rho' \mathbf{u}' \rangle$, heat flux $\langle q' \mathbf{u}' \rangle$, momentum fluxes $\langle \mathbf{u}' \mathbf{u}' \rangle$ and $\langle \mathbf{b}' \mathbf{b}' \rangle$, as well as the turbulent electromotive force $\langle \mathbf{u}' \times \mathbf{b}' \rangle$, are derived from the fundamental equations (ρ': density fluctuation, $\mathbf{u}'$: velocity fluctuation, q': internal-energy fluctuation, $\mathbf{b}'$: magnetic-field fluctuation). The transport coefficients are expressed in terms of the propagators (correlation and Green's functions) of MHD turbulence. In the presentation, the following two points will be stressed: (i) in a system with broken mirror-symmetry, dynamic balance between the enhancement and suppression of turbulent transports determines the system evolution; (ii) in the presence of strong compressibility, turbulent transports directly connected to the density variance $\langle \rho'^2 \rangle$ can strongly affect the turbulent transports. These features are expected to play important roles in the turbulent transport associated with shock waves and magnetic reconnections, where the compressibility and inhomogeneities in density, flow, magnetic field, etc. are of essential ingredients.