Gyrokinetic turbulent heating

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Abstract

Expressions for particle and energy fluxes and heating rates due to turbulence are derived. These fluxes and heating rates are identified from moments of an extended drift-kinetic equation for the equilibrium distribution function. These include neoclassical as well as turbulent diffusion and heating. Phase-space conservation is demonstrated, allowing the drift-kinetic equation to be expressed in conservative form. This facilitates taking moments with few approximations, mainly those consistent with drift kinetics for the equilibrium distribution function and the relative smallness of the fluctuations. The turbulent heating is uniquely defined by choosing the standard gyrokinetic definition for the energy flux. With this definition, most of the heating can be expressed in the form of ohmic heating from turbulent parallel and perpendicular current density perturbations. The latter current is identified with grad-B and curvature drifts, plus terms involving magnetic perturbations (which are smaller for low beta). A small contribution to the heating comes from the divergence of an energy flux which is dependent on the finite gyroradius of the ions. The fluxes and heating rates are expressed in a form which can be easily evaluated from gyrokinetic turbulence simulations.

PACS Nos.: 52.35Ra, 52.25Fi, 52.30Gz, 52.55Fa, 52.65Ti