Nonlocal thermal transport in magnetized plasma along different directions

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Thermal transport plays a critical role in inertial confinement fusion, which leads to fusion target compression and heating. It is well-known that the classical Spitzer–Härm theory for thermal transport becomes invalid when steep temperature gradients are found in laser-produced plasmas, where the thermal transport is shown to be nonlocal. Nonlocal thermal transport is also widely found in other plasma systems, such as magnetic fusion devices, astrophysical environments and general laser plasma interaction. In magnetized plasmas, the transport coefficients appear as a tensor and they are classically given by the Braginskii theory. Generally, the magnetic fields tend to inhibit and divert the heat flux, and nonlocal thermal transport also takes place in magnetized plasmas with steep temperature gradients.

In this work, the nonlocal thermal transport in magnetized plasma is studied theoretically and numerically with the Vlasov-Fokker–Planck (VFP) model, where the magnetic field has components both perpendicular to and along the temperature gradient. Nonlocal thermal transport is found both in the longitudinal and transverse directions as long as the temperature gradients are sufficiently large. The magnetic field tends to reduce the non-locality of the thermal transport in the direction perpendicular to the magnetic field, i.e., the difference between the heat fluxes predicted by the Braginskii's theory and the VFP simulation decreases with the magnetic field strength. When the temperature gradient is steep, the contribution of higher-order terms in the spherical harmonic expansion of the electron distribution function becomes important, in particular, for the thermal transport in the direction perpendicular to the temperature gradient even for weakly magnetized plasma.