An algorithm for accurate momentum transport in $\delta f$ PIC codes.

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Momentum fluxes can be difficult to accurately predict using current turbulent transport codes, especially in the so-called low-flow limit, where flows are ordered to be near the drift velocity. Such low flows are expected to arise for large tokamaks with negligible torque input, near up-down symmetry, and an effective zero rotation at the plasma edge. The essential problem is that, unlike for particle or heat fluxes, for such tokamaks the lowest order momentum fluxes cancel and the resulting residual flux is very sensitive to next-order terms which have often been neglected.

In addition, the results become sensitive to numerical errors in momentum transport: we examine how large these errors are for a $\delta f$ code and describe an algorithm to substantially improve the consistency of momentum transport for global scale analysis of large systems. The algorithm uses gyro-density fluxes to evolve the radial electric field to ensure that charge is exactly conserved within the numerical system.

As an application of this technique, we determine the residual fluxes which arise as a result of finite-system-size modifications to the ion distribution function. These effects (Barnes et al., PRL 111, 05055, 2013) are considerably larger than naive estimates would suggest. We show that direct global simulations are sufficient to accurately determine the fluxes due to the modified particle distributions and consistently evolve the corresponding profiles in medium-size devices.