A generalized tagging transfer function for lagrangian particle phase-space diagnostics

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We develop a formalism and explicit expressions for the optical-pumping transfer function between two laser beams immersed in a plasma that includes the effects of Fokker-Planck collisions and particle drifts. Typically, Eulerian (imaging and multi-fixed point) diagnostics are used to describe plasmas. These are measurements that measure densities, flow speeds, or distribution functions as functions of space, time and perhaps particle velocity. Lagrangian diagnostics of plasma ions based on optical pumping can provide information on particle orbits and Lagrangian correlation functions. From a Lagrangian measurement one obtains a conditional two-point probability function for particle orbits (the probability of certain final coordinates given the initial coordinates and the elapsed time $\Delta t$). In principle either approach (Lagrangian or Eulerian) is complete, but for many processes - especially processes that are either turbulent or chaotic - the connection between the two perspectives is so complex that they provide information that is more complimentary than redundant. Unfortunately, Lagrangian measurements present a number of difficulties, both in implementation and in interpretation that make them exceedingly rare. Here we address the problem of interpreting Lagrangian diagnostics based on the optical pumping of ions (ion tagging) and generalize expressions obtained earlier [1] for the tagging transfer function to include the effects of Coulomb collisions (by means of a Fokker-Planck operator) and particle drifts. Twelve of the thirteen integrals involved are evaluated analytically so that the final expression can be evaluated rapidly on an ordinary PC computer.

References