A model of electron transport from self-consistent action-angle transport theory[1]

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An explicit electron transport model is derived from a version of the action-angle collision operator that includes both a diffusion term and a friction term in action-space [2]. By adopting the adiabatic invariants of the unperturbed particle motion and their conjugate angles as phase-space coordinates, the theory describes the degradation of the plasma confinement as a result of the breaking of the invariants by wave-particle resonances. The friction term, missing in the quasilinear approach, describes the back-reaction of the particles on the fluctuations, giving to the model that property of self-consistency that is often crucial in predicting correct transport rates. With regard to the fluctuation spectrum, the theory is structurally similar to quasilinear theory in that it does not determine the spectrum, but rather accepts whatever spectrum one believes to correctly describe a particular transport mechanism. This provides a common framework to view the effects on transport of perturbations of very short wavelength, which give rise to collisional transport, or of longer wavelengths in the turbulent range.

After giving an overview of the general formalism, we specialize to passing electrons in tokamaks and study their transport induced by magnetic turbulence. We perform all the mathematical steps required to translate the random-walk in action space into more familiar radial transport, obtaining the complete set of transport equations, including a generalized version of the Ohm's law [3]. We discuss the properties of the resulting model, and suggest useful extensions.

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[2] D.A. Hitchcock, R.D. Hazeltine and S.M. Mahajan, Phys. Fluids **26**, 2603 (1983); H.E. Mynick, J. Plasma Phys. **39**, 303 (1988).

[3] R. Gatto and I. Chavdarovski, Phys. Plasmas **14**, 092502 (2007); I. Chavdarovski and R. Gatto, in preparation.