# Toroidal momentum transport in a tokamak due to small scale instabilities

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This paper will discuss the progress in the understanding of anomalous toroidal momentum transport in a tokamak. Both the diagonal (diffusive) as well as the pinch contribution will be discussed.

The diffusion coefficient of toroidal momentum has been calculated within the gyro-kinetic framework using both quasi-linear theory as well as non-linear simulations. In the quasi-linear approach a large number of simulations have allowed for the determination of the Prandtl number (Pr, the ratio of the momentum diffusivity to the ion heat conductivity) as a function of the plasma parameters. In general the value of Pr is in the range 0.7-1.2 and depends little on the plasma parameters. Pr is larger when kinetic electrons are considered and increases when the plasma is closer to the threshold of the ion temperature gradient mode (the mode considered here). Non-linear simulations have been reported to yield a Prandtl number of 0.8 for the Waltz standard case. It is tempting to assume that the linear and non-linear results are equivalent, and although they are indeed similar, recent non-linear simulations have revealed significant differences. In the talk the non-linear results will be presented and the differences will be discussed.

Two main effects are known to generate a momentum pinch velocity: The ExB shearing and the Coriolis drift effect. The origin of both effects will be discussed in detail, and again linear and nonlinear theory will be compared. It will be shown that the nonlinear simulations reproduce the effects predicted in linear theory (see example below), and that the scaling with plasma parameters is roughly similar. Again there are some differences between linear and non-linear simulations which will be discussed in detail. Furthermore the relation with the Turbulent equipartition theory and the theory of resonant particles will be clarified. Finally, the magnitude of the two known effects will be compared.

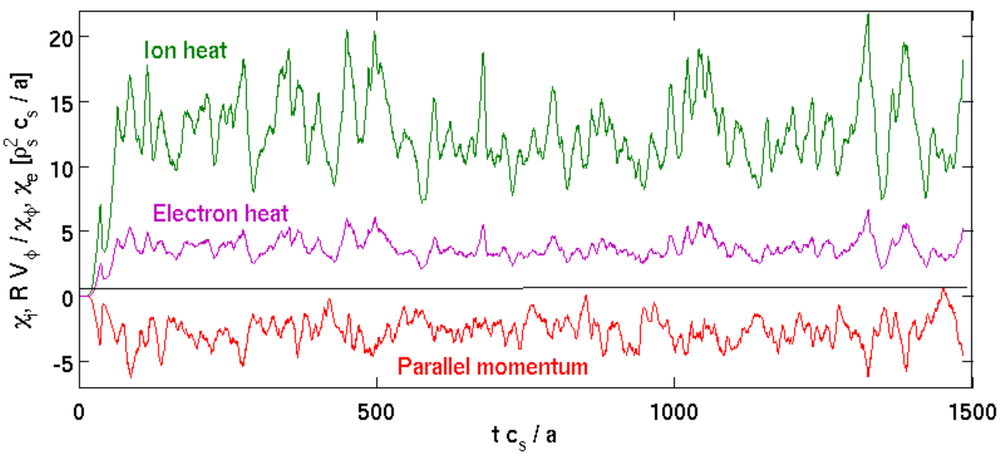


*Fig.1 Ion and electron heat conduction coefficient as well as the dimensionless pinch velocity as a function of time in a nonlinear run. The momentum flux is negative and therefore directed inward.*