# Electromagnetic effects in momentum and particle transport

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Gyrokinetic studies of electromagnetic effects on toroidal momentum and electron particle transport are presented [1,2]. It is shown that in both cases magnetic field fluctuations described by the inclusion of Ampère's law in the gyrokinetic model imply a reduction of the inward convection of momentum and of electrons in ion temperature gradient turbulence. The physical mechanisms behind these similar behaviours are indeed different in the two transport channels, but can be in both cases ultimately attributed to the non-adiabatic response of passing electrons induced by magnetic field fluctuations. In the case of the transport of toroidal momentum, magnetic fluctuations affect the mode eigenfunction and lead to an increase of the parallel wave number and a reduction of the Coriolis pinch [3]. In addition, in the presence of electromagnetic instabilities like microtearing modes, the variation of the real frequency can lead to a total outward convection of toroidal momentum. In contrast, in the case of electron particle transport, the main effect is directly connected with an outward convection of passing electrons, which reduces the inward convection of trapped electrons. Analytic studies are supported by numerical simulations, with the codes GYRO, GS2 and GKW. These theoretical results have an important impact on the predicted plasma profile shapes of high beta scenarios in the absence of strong external fuelling and torque from neutral beam injection, and therefore should motivate dedicated experimental investigations. In fact, in the absence of strong neutral beam injection, high beta operation close to the kinetic ballooning limit, like in present hybrid scenarios, is expected to lead to a significant reduction of density peaking, and a strong flattening of the toroidal rotation velocity profile, due to the combined effect of the increase of beta and the concurrent reduction of the logarithmic density gradient.

[1] T. Hein et al, Phys. Plasmas **17**, 102309 (2010).
[2] T. Hein et al, Phys. Plasmas to be submitted (2011).
[3] A.G. Peeters et al, Phys. Rev. Lett. **98**, 265003 (2007).