The structure, evolution and role of the edge radial electric field in H-mode and L-mode on MAST

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The radial electric field, E_r, in edge of a tokamak plasma is intimately connected to the formation and strength of the edge transport barrier (ETB). It is widely accepted that the shear in the $E \times B$ flow de-correlates the density and electric field fluctuations in the edge and reduces turbulent transport leading to the increased confinement in H-mode. It has also been shown that an externally induced electric field can prompt L/H transitions.

Only on a few devices in the world can the structure of the edge electric field be measured accurately enough to be compared to code calculations. Here, we will discuss the first measurements of the structure of E_r in spherical tokamaks, and MAST in particular. The field is determined by calculating the leading terms of the radial momentum balance with the help of the toroidal and poloidal impurity velocities obtained from passive Doppler spectroscopy of He^+. The new instrument has a spatial resolution of about $\Delta r \approx 1.5$ mm after deconvolution with 59 toroidal and 60 poloidal lines of sight. The typical time resolution is $\Delta t = 5$ ms.

In L-mode the toroidal and poloidal He^+ velocities are very low ($-5\ \mathrm{km/s} \lesssim v^{\mathrm{L}}_{\phi,\theta} \lesssim 5\ \mathrm{km/s}$) with flat profiles slightly increasing towards the edge. The electric field at the peak emission is about $E_r^{\mathrm{L}} = -0.5\ \mathrm{kV/m}$. In H-mode the toroidal He^+ flow shows a strong negative shear of $\partial v^{\mathrm{H}}_{\phi}/\partial r \approx 3 \cdot 10^6\ \mathrm{s}^{-1}$ over the first $\Delta R = 5$ mm inside the last closed flux surface, with a co-current flow at the separatrix followed by a negative well of about 20 mm width. The poloidal velocity has a comparatively flat profile with values around $v^{\mathrm{H}}_{\theta} \approx -15\ \mathrm{km/s}$. The electric field at the peak emission, however is only $E_r^{\mathrm{H}} = -3.6\ \mathrm{kV/m}$, but is more negative towards the edge.

The toroidal and poloidal He^+ flow, and hence their contributions to E_r evolve on different time scales. The poloidal velocity evolves very fast and stays constant during long ELM free phases, whereas the toroidal velocity evolves at a slower time scale. The effect of plasma parameters, fuelling location, the magnetic configuration, and low n error fields on the flows and E_r will also be discussed in the paper.

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