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Direct evidence of stationary zonal flows and critical gradient behavior for E_r during formation of the edge pedestal in JET*

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High spatial resolution measurements with Doppler backscattering in JET have provided new insights into the development of the edge radial electric field during pedestal formation. The characteristics of E_r have been studied as a function of density at 2.5 MA plasma current and 3 T toroidal magnetic field. We observe fine-scale spatial structure in the edge E_r well prior to the LH transition, consistent with stationary zonal flows. Zonal flows are a fundamental mechanism for the saturation of turbulence and this is the first direct evidence of stationary zonal flows in a tokamak. The radial wavelength of the zonal flows systematically decreases with density. The zonal flows are clearest in Ohmic conditions, weaker in L-mode, and absent in H-mode. Measurements also show that after neutral beam heating is applied, the edge E_r builds up at a constant gradient into the core during L-mode, at radii where E_r is mainly due to toroidal velocity. The local stability of velocity shear driven turbulence, such as the parallel velocity gradient mode, will be assessed with gyrokinetic simulations. This critical E_r shear persists across the LH transition into H-mode. Surprisingly, a *reduction* in the apparent magnitude of the E_r well depth is observed directly following the LH transition at high densities. Establishing the physics basis for the LH transition is important for projecting scalings to ITER and these observations challenge existing models based on increased E_r shear or strong zonal flows as the trigger for the transition.

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