Effect of the density increase on confinement

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After every event of ionization of a neutral particle in plasma it follows a displacement of the newly born charges (electron and ion) towards the equilibrium orbits. They leave the magnetic surface where they have been created, due to the neoclassical drift, and evolve towards stationary trajectories. Since the electrons move much less than the ions, the main effect is associated with the newly born ions. Neglecting collisions, the ions will settle on circulating or trapped orbits and during the periodic motions they depart radially form the magnetic surface alternatively to larger and respectively to smaller radius. Since these radial deviations relative to the magnetic surface are compensating, the time average shows no effective radial displacement: the orbit has an effective "center" which corresponds to the spatial average of the successive positions of the ion (for example: the "center" of a banana; we neglect small neoclassical motions of this "center"). However there is a part in the radial excursion of the new ions which remains uncompensated. This is precisely the first interval, just after the ionization, when the ion has evolved to take the periodic trajectory, and its successive positions do not yet average to the "center". This displacement, from the place where ionization takes place, towards the "center" of the final trajectory, is an effective radial current. This radial current is a source of rotation and in this way has an impact on the quality of the confinment. It effectively makes a connection between the density increase (via pellets or "density puff") and the confinment. We note that there is a considerable experimental evidence that the variation of density produces a change in the quality of the confinment. On a fast time scale a radial electric field is generated by the charge separation (the electrons are tied to the magnetic surfaces, while the ions will travel with $v_{Di} = v_{th,i} / (\Omega_{ci} R)$ to their "center"). A simple estimation is $\partial E / \partial t \sim (\delta R) |e| \dot{n}_{ioniz} / \varepsilon_0$. In response there is a polarization drift of the bulk ions $v_{Di}^{(pol)} = (\partial E / \partial t)(\Omega_{ci} B)^{-1}$. We estimate the radial current as $J_r = -v_{Di} \frac{1}{2} |e| \dot{n}_{ioniz} \tau_{ioniz} \left(\frac{\partial S}{\partial r}\right)_{x_C} 2\rho_i q \varepsilon^{-1/2}$ and obtain an order of magnitude of the rate of the torque. Compared with the magnetic damping , the ionization-induced rate is about two orders of magnitude greater. Here δR is the radial extension of the region affected by the ionization, $\partial S / \partial r$ is the radial variation of the local rate of ionization, $\dot{n}_{ioniz}$ is the total rate, τ_{ioniz} is a characteristic time, as the time of ablation of a pellet. Several interesting conclusions arise: (1) the effect of the ionization on the confinement (via the induced rotation) can be substantial, especially at the edge; (2) there is a positive effect of the *atomic mass* A on the confinement. (3) Some improved regimes in JET („pellet enhanced performance"), DIII-D and confinement changes observed in TCV and Alcator C-MOD appear to be connected with this effect of density variation.