Edge plasma instabilities: impact of plasma flow velocity shear and neutrals

S.I. Krasheninnikov[1], Y. Zhang[1], A.I. Smolyakov[2], M. Medrano[1]

[1] *University California San Diego, La Jolla, USA*

[2] *University of Saskatchewan, Saskatchewan, Canada*

There is a long-lasting interest in the impact of plasma velocity shear and neutrals on tokamak edge plasma instabilities and turbulence. Whereas it is widely believed that velocity shear, V', could suppress plasma instabilities and stimulate the transition from low (L-) to high (H-) confinement modes, the underlying physics of plasma instability suppression is still not clear. Often it is assumed that the stabilization of plasma instability characterized by the growth rate occurs when by the velocity shear exceeds [1]. One of the complications of the analysis of the velocity shear effect on plasma instabilities is the non-Hermitian nature of the differential equations describing an impact of velocity shear on plasma/fluid instabilities [2]. However, we find that the situation is more complex and just effective Richardson number, Ri, does not describe the impact of velocity shear. Considering the gradual step-like "radial" density profile and analyzing the eigenmode solutions, we find [3] that for larne "poloidal" wavelength the growth rates of both fluid Rayleigh-Taylor (RT) and plasma interchange (I) modes could be significantly reduced even for Ri>>1. On contrary, the resistive drift waves (RDW) are not stabilized even for Ri<<1. Moreover, whereas the eddies of both RT and I modes in the presence of V' become tilted into poloidal direction, those of the RDW become just shifted into the radial direction, but cease to exist at large V'. The results of numerical non-modal solutions of linear RDW for large V' will be presented. Unlike the effect of velocity shear, the results of the studies of an impact of neutrals on edge plasma instabilities and turbulence are somewhat controversial. Whereas some experiments show no effect of neutrals on edge plasma turbulence, others demonstrate importance of neutrals for L- to H-mode transition [4]. Similarly, some simulations show that neutrals result in increasing edge plasma turbulence, whereas some others claim the opposite effect [5]. We perform a careful analysis of the effect of neutrals (ranging from kinetic to fluid transport regimes) on interchange, RDW, and instabilities [6] and find that in practice neutrals make a very minor impact on these instabilities, although in dense divertor plasma an impact of neutrals on plasma stability could be important (see Ref. 7 and the references therein). However, neutrals can significantly alter the generation of zonal flow by plasma turbulence (e.g. by DW turbulence [8]) and by that modify edge plasma turbulence and transport.

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