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Impact of plasma flow velocity shear and neutrals on edge plasma instabilities

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γ_{inst}

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ABSTRACT

- Contrary to some widely spread believes, the is no universal relation between the growth rate of the instability and the velocity shear describing the reduction of an instability growth rate .
- Neutrals start to alter turbulence transport at the densities where there is no effect on linear instabilities and zonal flow generation growth rates possible. But, even modest reduction of the developed zonal flow magnitude by neutrals causes a pronounced impact on anomalous edge plasma transport .

BACKGROUND

- There is a long-lasting interest in the impact of plasma velocity shear and neutrals on tokamak edge plasma instabilities and turbulence.
- Often it is assumed that the stabilization of plasma instability characterized by the growth rate, γ, occurs when by the velocity shear, V’, exceeds γ.
- An impact of neutrals on edge plasma turbulence was not clear and in the preceding publications is ranged from the reduction of instabilities growth rates, the modification of turbulence spectra, and to complete suppression of a zonal flows.

CHALLENGES / METHODS / IMPLEMENTATION

IMPACT OF SHEAR FLOW

We consider an impact of a constant shear flow on the Rayleigh-Taylor, Interchange mode (IM) and resistive drift wave (RDW) instabilities.

We perform both analytic and numerical studies of the impact of the shear flow on both the growth rates and the 2D structures of the eigenfunctions of the corresponding modes

IMPACT OF NEUTRALS ON TURBULENT TRANSPORT IN EDGE PLASMA

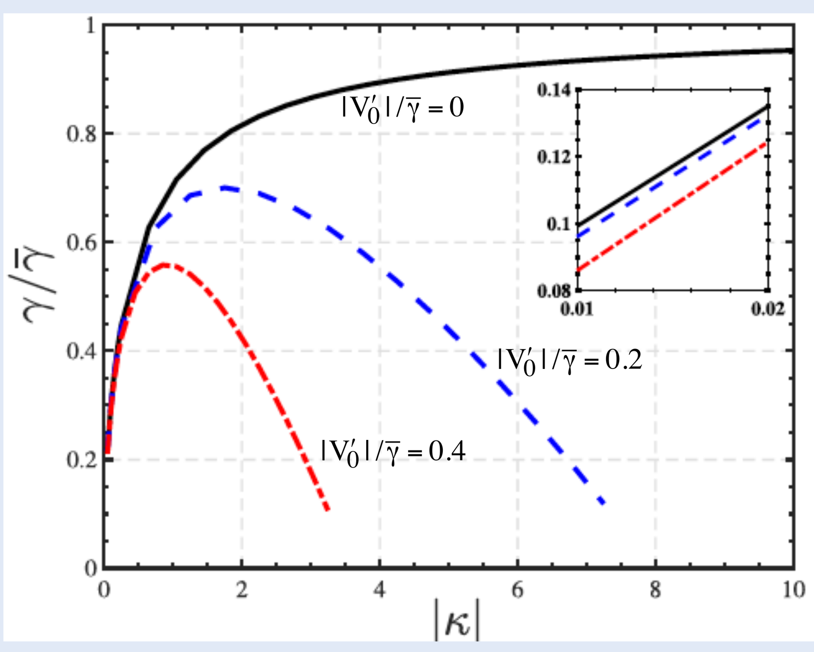
We consider the RDW instability as a proxy for the key driving instability

We choose the neutral density which do not alter either the linear growth rate of the RDW instability or linear growth rate of zonal flow generation by developed RDW turbulence

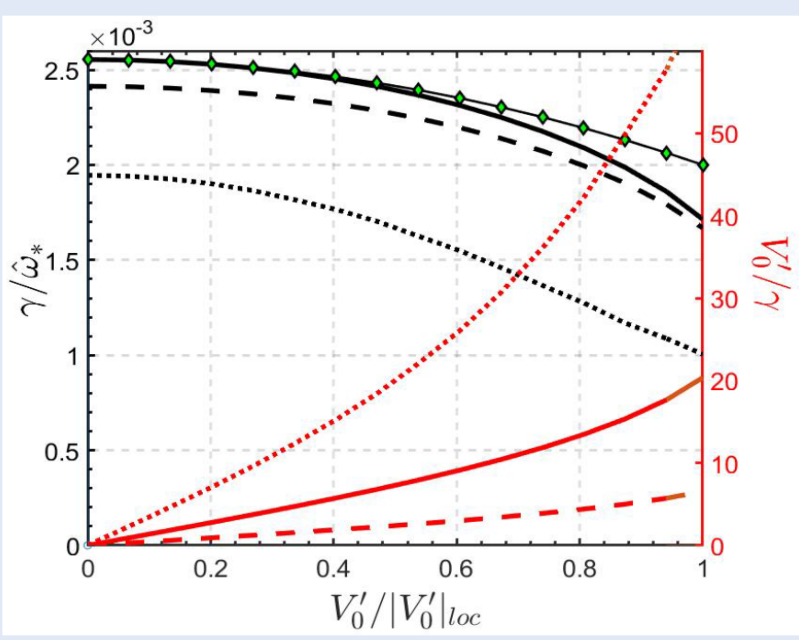
We perform nonlinear simulation of an impact of neutrals on plasma transport driven by the RDW turbulence

DETACHMENT AND EDGE PLASMA TURBULENT TRANSPORT

To assess the magnitude of averaged neutral density in the vicinity of the separatrix for DIII-D-like plasma in detached divertor regime we perform a series of numerical simulations with the UEDGE code.



1. Significant stabilization of the IM by velocity shear



2. Weak stabilization of the RDW instability by velocity shear

OUTCOME

SHEAR STABILIZATION

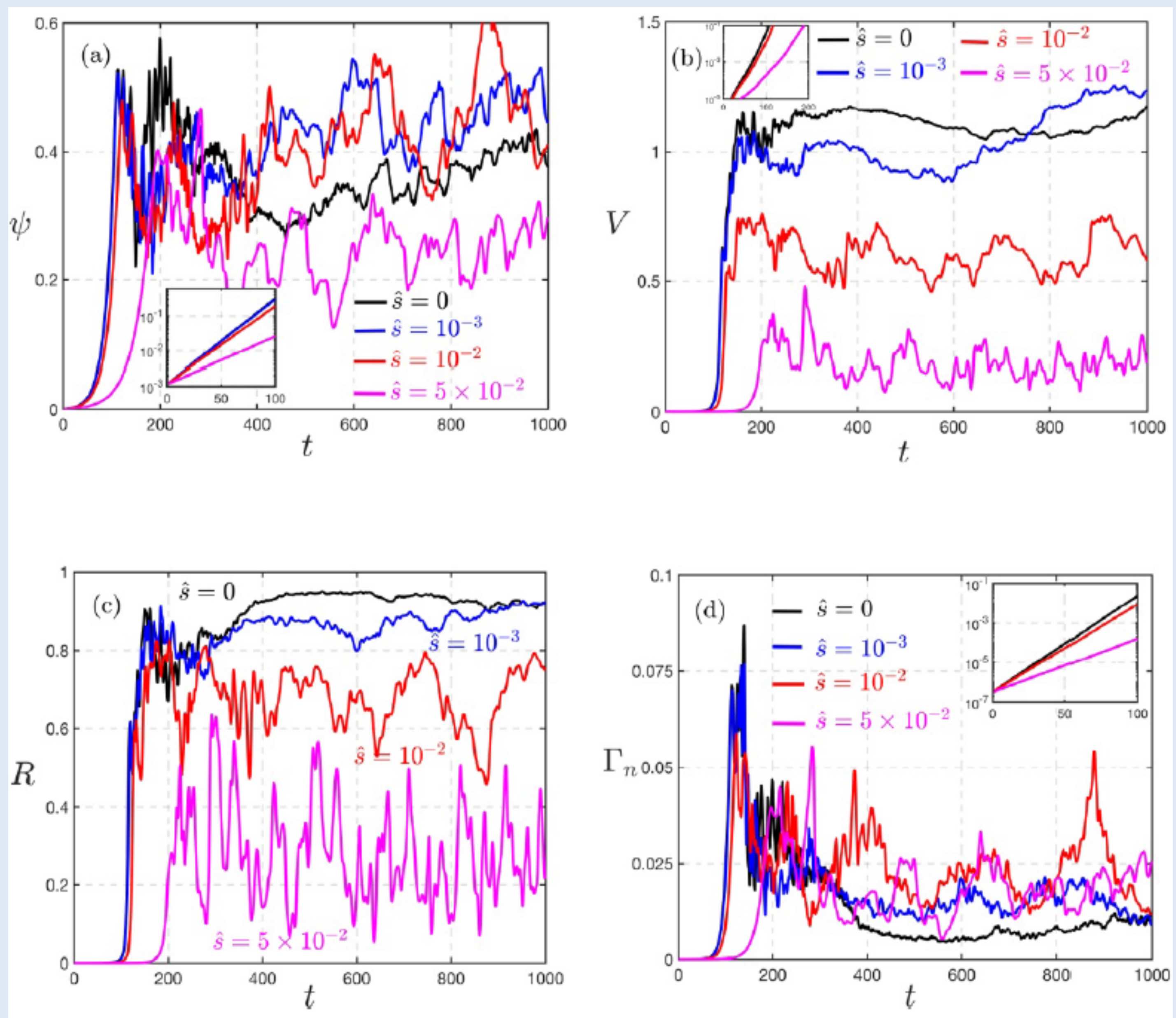
We found that whereas the growth rates of RT and IM could be significantly reduced by velocity shear, it has very small impact on the growth rate of the RDW instability (see Fig. 1,2) .

NEUTRALS AND EDGE PLASMA TURBULENT TRANSPORT, IMPACT OF DIVERTOR DETACHMENT

Even though neutrals do not alter either the growth rate of edge plasma unstable modes or linear generation of ZF, in nonlinear regime of even a small reduction of ZF causes significant variation of anomalous plasma transport

Our simulations show that at neutral density ~10^{10} cc plasma flux can increase by factor of two (see Fig. 3)

Our UEDGE simulations of divertor detachment of DIII-D like plasma show that such neutral density can be increased at the separatrix, which could explain edge transport enhancement in detached regimes seen in experiments



3. The evolution of the RMS of electrostatic potential fluctuations (a), Zonal Flow (b), the ratio of ZF energy to total energy (c), and anomalous Plasma flux (d). S=0, 10^{-3}, 10^{-2}, and 5×10^{-2} corespond to neutral densities (0, 1, 10, 50)×10^{10} cc.

CONCLUSION

- Shear stabilization is very sensitive to the type of the mode
- Neutrals start altering edge plasma transport at densities ~10^{10} cc
- The details of these studies could be found in: Y. Zheng, S. I. Krasheninnikov, and A. I. Smolyakov, Phys. Plasmas **27** (2020) 020701; Y. Zheng and S. I. Krasheninnikov, Plasma Phys. Contr. Fusion **62** (2020) 115018; Y. Zheng, S. I. Krasheninnikov, R. Masline and R. D. Smirnov, Nucl. Fusion **60** (2020) 106023

ACKNOWLEDGEMENTS / REFERENCES

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