Congress on Numerical Methods in Engineering CMN2017
Valencia, 3-5 July, 2017

# A hybrid discontinuous Galerkin method for tokamak edge plasma simulations – CNM 2017

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## ABSTRACT

The success of the fusion operation in future tokamaks is conditioned by the quality of plasma confinement in the core of the reactor and by the control of heat exhaust. Transport in tokamak is governed by turbulence that is therefore strongly linked to confinement performance. As such, it adds considerable complexity in achieving the necessary conditions to sustain burning plasmas while maintaining sustainable power fluxes on the wall. The design of optimized operation scenarios for ITER will be based on predictions made from engineering numerical simulations whose reliability is still acknowledge by the international community as being an issue. In this context, this calls for an important modelling effort in the prediction of transverse transport. Progressing towards predictive simulations requires both to progressively enrich the physics included in the models and to continuously improve the accuracy and efficiency of the numerical schemes.

As an attempt to achieve this goal we explore here the use of a high-order hybrid discontinuous Galerkin (HDG) finite element method [1] for solving a reduced fluid model of transport equations for the ion density n and the particle flux Γ in the direction parallel to the magnetic field. In this model, the convective parallel transport, governed by nonlinear hyperbolic equations is dominant while the perpendicular transport is only diffusive. This reduced model [2] contains however most of the challenging issues regarding accurate numerical simulations: a strong flow anisotropy, the plasma wall interaction and the periodicity breaking between the edge region with closed magnetic field lines and the SOL region, where field lines are intercepted by wall components. With respect to existing 2D transport codes, generally based on first and second-order finite-differences / finite-volumes numerical schemes, this scheme provides accurate geometry description of the tokamak chamber with the use of curved elements, sharp resolution of the steep temperature and density gradients thanks to the high-order polynomial interpolation, and accurate, robust and efficient computations by reducing the undesired numerical dissipation and dispersion, and therefore the required number of degree of freedom for a given accuracy.

Some challenging numerical examples on real tokamak geometries are presented to demonstrate the attractiveness of this new numerical approach.

## REFERENCES

[1] B. Cockburn, B. Dong, J. Guzmán A superconvergent LDG-hybridizable Galerkin method for second-order elliptic problems, Math. Comp. 77 (264) (2008) 1887–1916.

[2] Isoardi L., Chiavassa G., Ciraolo G., Haldenwang P., Serre E., Ghendrih Ph., Sarazin Y., Schwander F., Tamain P. Penalization modeling of a limiter in the tokamak edge plasma, *J. Comp. Phys.*, 229(6), 2220-2235, 2010