Synthetic and experimental diagnosis of fluctuations in the edge of fusion plasmas

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ANR SEDIBA (Simulation of Effective data and Diagnostic Signals at the Boundary of tokamak plasmas)
Context : Nuclear fusion

Thermonuclear fusion : energy of the stars

- How can we reproduce necessary conditions on Earth?
  \[ \frac{2}{3}D + \frac{3}{3}T \rightarrow \frac{4}{2}He \ (3.5 \ MeV) + n \ (14.1 \ MeV) \]
  - Magnetic confinement : tokamak configuration

Tokamak configuration
The edge plasma determines the conditions of plasma-wall interaction

- Control pollution of plasma (from products of erosion of the wall)
- Protection of nuclear fusion device: important particle flow and heat flow, turbulence (intermittency and patterns)
Synthetic diagnosis: comparing experiment/simulation

- **Experimental diagnosis:**
  - Langmuir probe: measure electronic density and temperature and electric potential
  - EM wave scattering: measure fluctuation

\[
V_{\perp} = V_{\text{plasma}}_{\perp} + v_{\text{fluc}} \\
\equiv V_{E \times B \perp} + \left\langle \frac{\omega}{k} \right\rangle_{\text{fluc}}
\]

- **SOLEEDGE 2D:**
  - Transport code (written by H. Bufferand): transport as diffusive process (no turbulence), a wide range of modular parameter
  - Computation of density, parallel flow, ionic and electronic temperature
  - Drifts neglected: no electric field implemented
Well documented extended experiments: the Mistral case test

- Principle: adjusting magnetic configuration to change plasma-wall contact point location
- Mach probe: parallel velocity
- Reproduction of this experiment by H. Bufferand in his PhD Thesis
  - Same trend for parallel mach number close to the separatrix
  - Differences in the far SOL


Simulation results for the 4 magnetic configurations, Mach number H. Bufferand, PhD Thesis 2012
Comparison of experiment and simulation results

- Density decay length recovered
- Differences may be linked to the presence of neutrals, the effects of drifts or the nature of transport
Work in progress: implement drifts compare radial electric field

- Implementation of electric drift in SOLEDGE set of equations
- Electric field is not self consistent
- Future work: implementation of other drifts velocities (diamagnetic, magnetic field line curvature, polarisation, …)

Perpendicular velocity \((E_rB)\) from Doppler reflectometry

\[ V_{\text{perp}} \text{ [km/s]} \]

P. Hennequin et al. EPS 2010
Objectives

- Development of a module to simulate experimental measure with any edge simulation code: better understanding of experimental measurement
- Study of fluctuation in edge plasma: understanding of improved confinement mode (mode H), study of radial transport at edge/core separatrix
Thank you for your attention!