Overview TSVV Task 4

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TSVV T1 Progress Workshop
22 October 2021

Setup of TSVV Task 4

Key deliverables:

1) Develop highly scalable **gyrokinetic / fully kinetic codes for the plasma edge**.
   Provide first versions to **TSVV T1** asap.

2) Develop new methods for **dealing with open field lines**.
   Find improved boundary conditions via FK studies, potentially coupling of GK/FK approaches

3) Explore **limitations of gyrokinetics: Compare GK/FK,** e.g. for strong gradients.
   Extensions to GK needed?

4) Code coupling methods for handling interaction with **neutrals and impurities**.
   Methods for **coupling GK and fully kinetic** approaches, plus **GK and fluid/gyrofluid** approaches.

Our setup:

1) Advance three codes in parallel: **GENE-X (IPP), PICLS (SPC), GyselaX (CEA)**

2) Combined numerical and analytical efforts: **BIT1**, **VOICE** simulations, **semi-analytical model** (grazing incidence)

3) Hybrid/fully kinetic codes **ssV** and **GEMPIC/AMReX**; **Moment-based** edge GK model

4) **Inclusion of neutrals planned for all main codes**, moving from simple source terms to more realistic models.

   Treat **impurities** either in-model, or by coupling to external simplified models.
   Coupling kinetic/fluid offered by moment-approach.

TSVV T4 Project Members

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GK codes

Sheath

Beyond GK

Coupling

K. Kormann replaced by **Dongjian Liu**

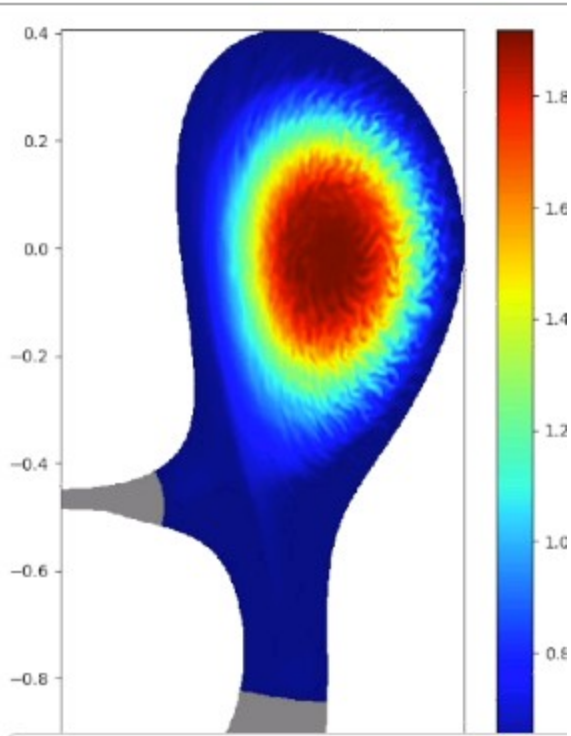Additional support by **D. Tskhakaya, L. Villard, J. Kovačič, F. Jenko**

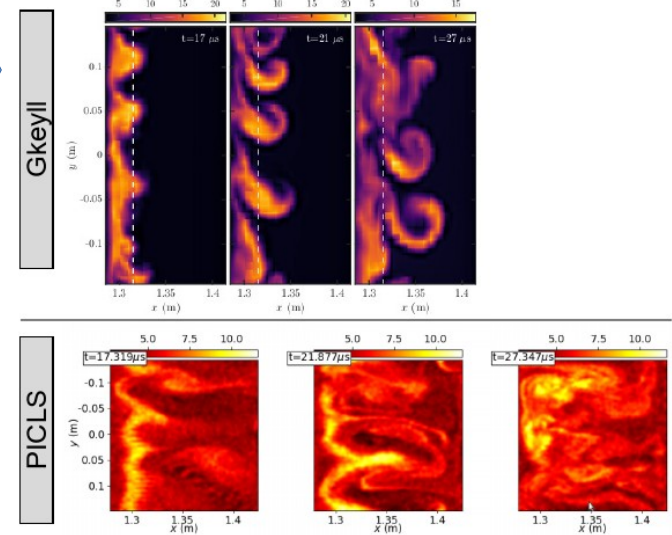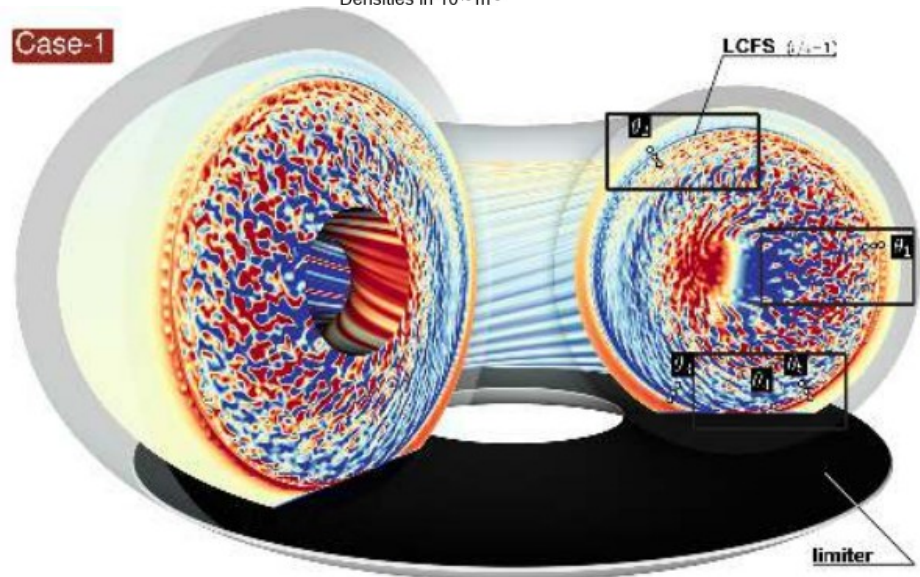# Quick glimpse of main code status

PICLS /
A. Bottino

Density comparison: Gkeyll vs. PICLS

Densities in 10^{18} m^{-3}

GENE-X /
D. Michels

GyselaX /
G. Dif-
Pradalier

Milestones for remainder of 2021

GENE-X

- Implementation of sheath boundary conditions for simple geometries.
- Implementation of collisions in stages, aiming for realistic Landau-type operators
- Implementation of sheath boundary conditions for arbitrary geometries.

GyselaX

- First simulation with particle source (prescribed, not self-consistent at this stage)

PICLS

- Full-F nonlinear collision operator
- Second order particle Lagrangian (nonlinear polarization equation)

Ab-initio sheath studies

- Providing sheath parameters and corresponding BCs by extracting them from the existing BIT1 simulation database

Immersed boundary sheath studies

- Identify critical parameters for sheath boundary conditions with kinetic electrons in VOICE

Analytical sheath studies for gyrokinetic systems

- Extension of sheath model by kinetic electron physics

Exploring the limits of Gyrokinetics

- Enable routine operation of ssV in 3D position space
- Introduce electromagnetic fluctuations to ssV
- Perform ITG simulations with varying gradients benchmark against pure gyrokinetics (ssV)

Coupling to neutral and impurity physics

- Develop source term formulation for neutral particle coupling to gyrokinetic equations

Exploring the gyrokinetic moment hierarchy

- Explore importance of kinetic effects for linear modes in tokamak boundary for different number of moments, benchmark with main codes and different collision operators (including a full linear Coulomb collision operator)

Project status

Introduced **focus groups** for topics of interest to several members:

- Solvers for **nonlinear Poisson** equation
- **Sheath boundary** conditions.

2 ACH projects started (GENE-X, GyselaX) in July.

Thank you for your attention!

Any questions,
comments,
are welcome!