Overview TSVV Task 4

D. Told
Thrust Meeting 09 July 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.

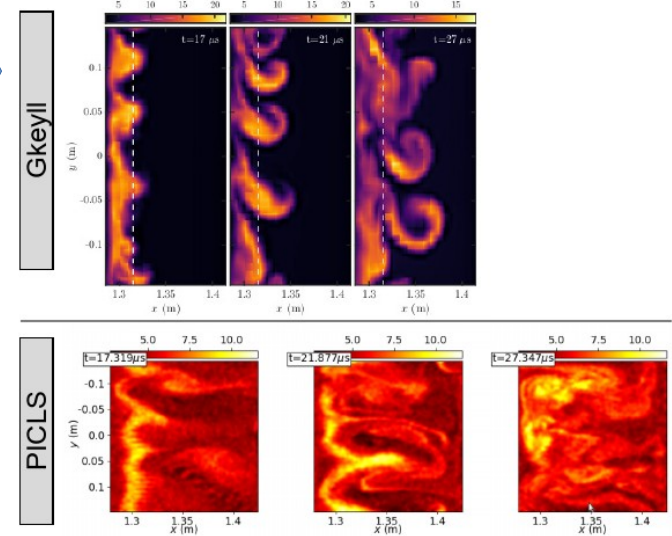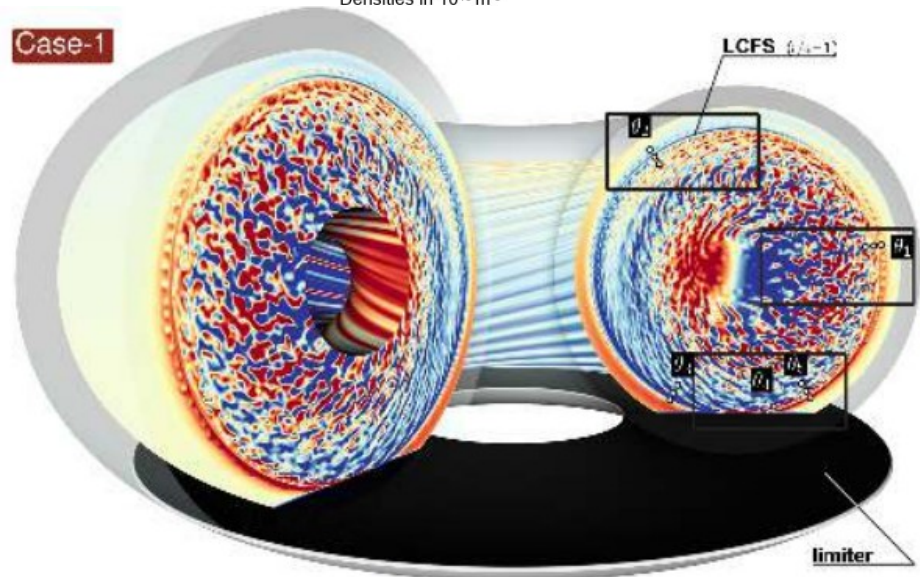# Quick glimpse of main code status
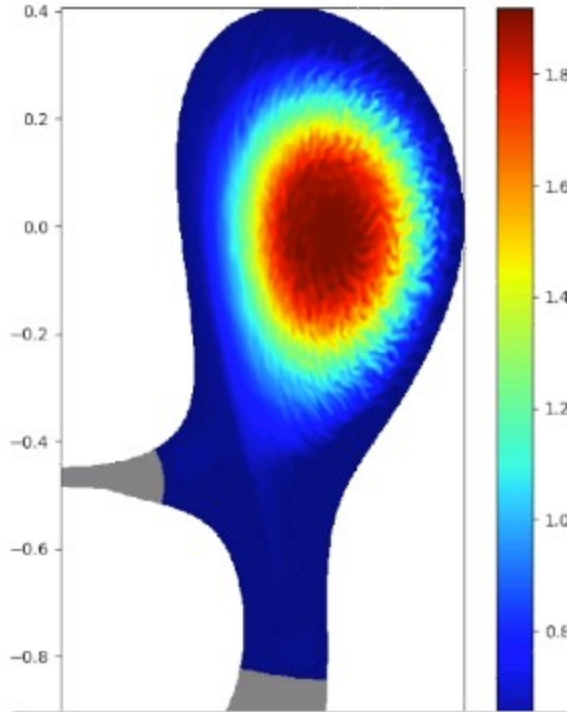
GENE-X /
D. Michels

PICLS /
A. Bottino

Density comparison: Gkeyll vs. PICLS

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

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

- **Personnel matters:**
  - 1 temporary replacement at IPP
- Implemented **monthly meetings** in June

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

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

HPC: Marconi resources available since March → 38% used
2 ACH projects approved (GENE-X, GyselaX).

First sheath subgroup meeting on July 13th, 15:00

- Interested people from other TSVVs?

Neutral physics: could interact here, too

Experimental input: Development preferentially on „cheap to run cases"

TSVV1: Physics of the L-H Transition and Pedestals	TSVV3: European boundary plasma modelling towards reactor relevant simulations	TSVV4: Plasma Particle/Heat Exhaust: Gyrokinetic/Kinetic Edge Codes
• GBS • GENE • GYSELA • HAGIS • ORB5 • QuaLiKiz • SOLEDGE3X • TSVV4 Code	• BIT1/BIT3 • EBC • FELTOR • GBS • GRILLIX • SOLEDGE3X	• GENE-X • GyselaX • PICLS • BIT1/BIT3 • VOICE

N. Vianello | TSVV & ACH KoM | 23 April 2021 | Page 5

Thrust 1: Pedestal & SOL Turbulence

Facilitator: **N. Vianello (M. Wischmeier)**   [WPTE]

Involving: T. Görler; P. Tamain; D. Told   [TSVV-1, -3, -4]

A. Alonso; S. Brezinsek   [WPW7X, WPPWIE]

E. Serre; C. Roach   [AC SB]

Thank you for your attention!

Any questions,
comments,
are welcome!