EUROfusion

Overview of activities of interest for the optimization of stellarator turbulent transport in TSVV 13

J. M. García Regaña on behalf of the TSVV13 Team

P.I. for the *TSVV13 Stellarator Turbulence Simulation*

Thrust 4: Stellarators

Meeting on optimization of turbulent transport

October 7th, 2022

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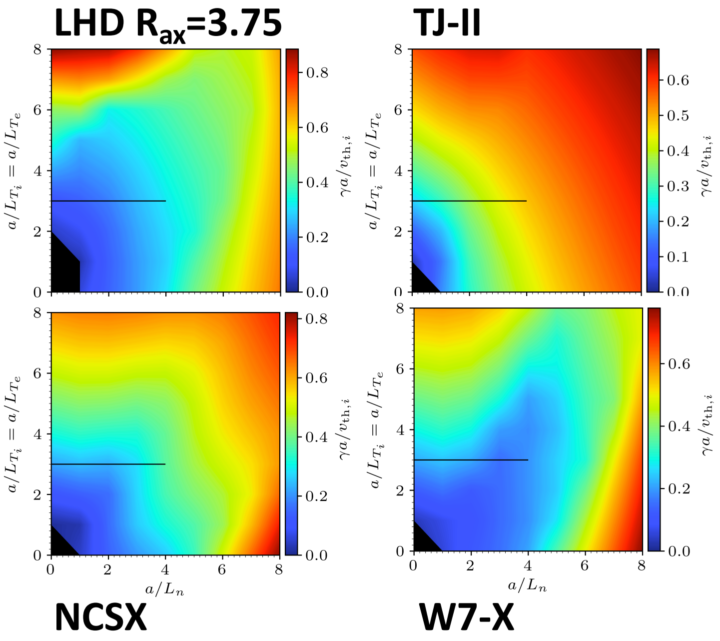
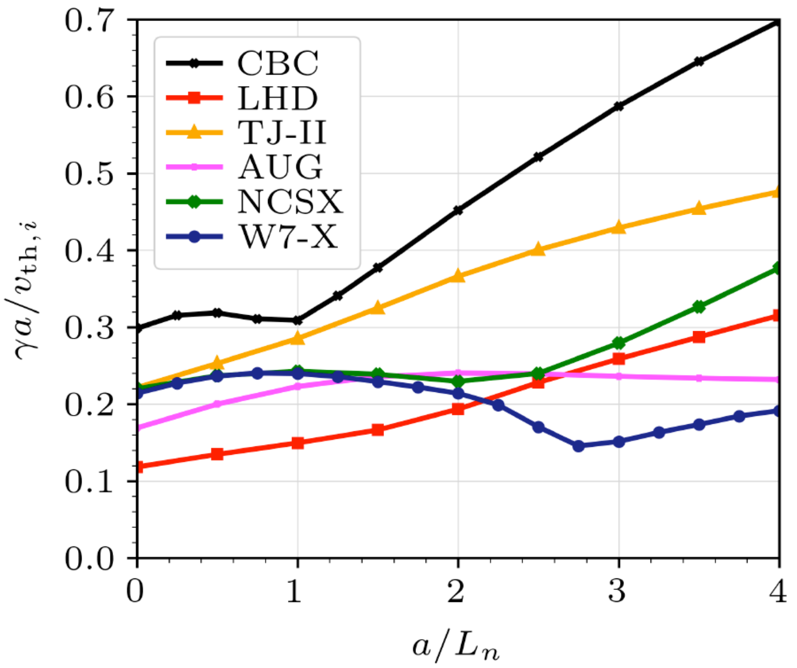
Multi-machine comparison of stability and nonlinear fluxes

- Cross-machine comparison of electrostatic stability has been carried out with **`stella`** [Thienpondt ISHW´22].



$$r/a = 0.7, a/L_{T_e} = a/L_{T_i} = 3$$



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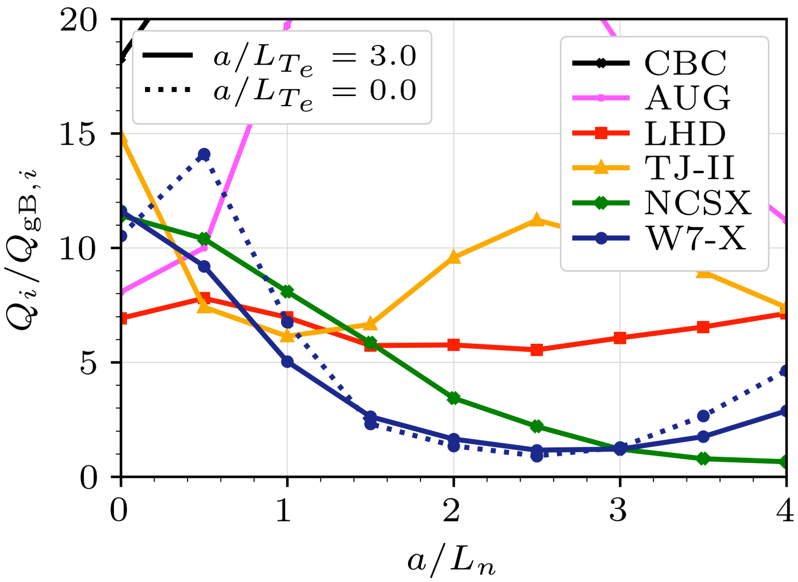

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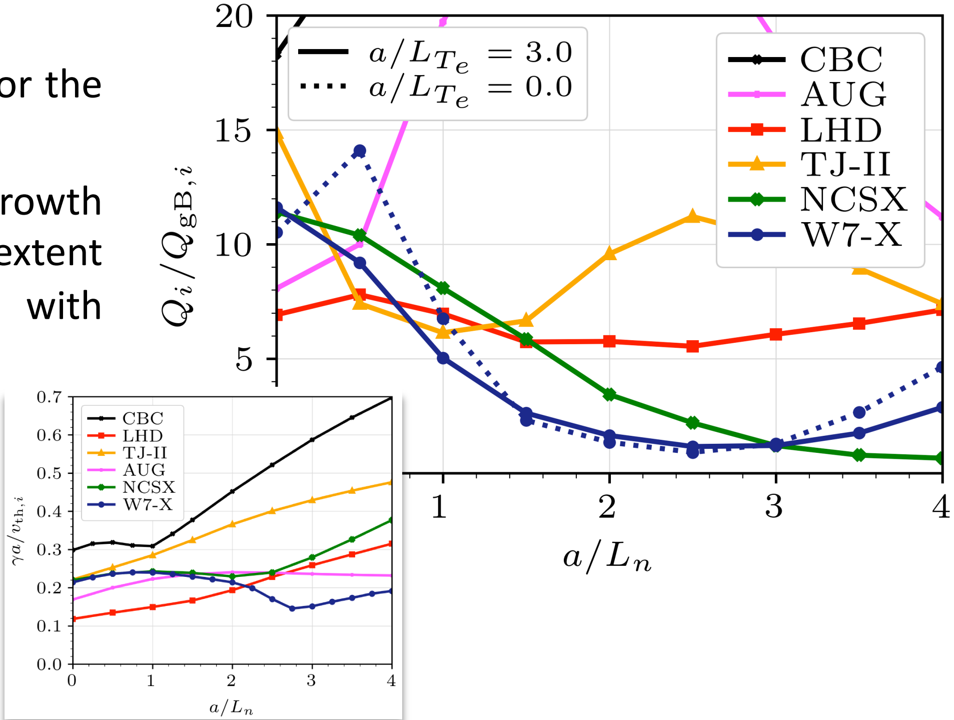

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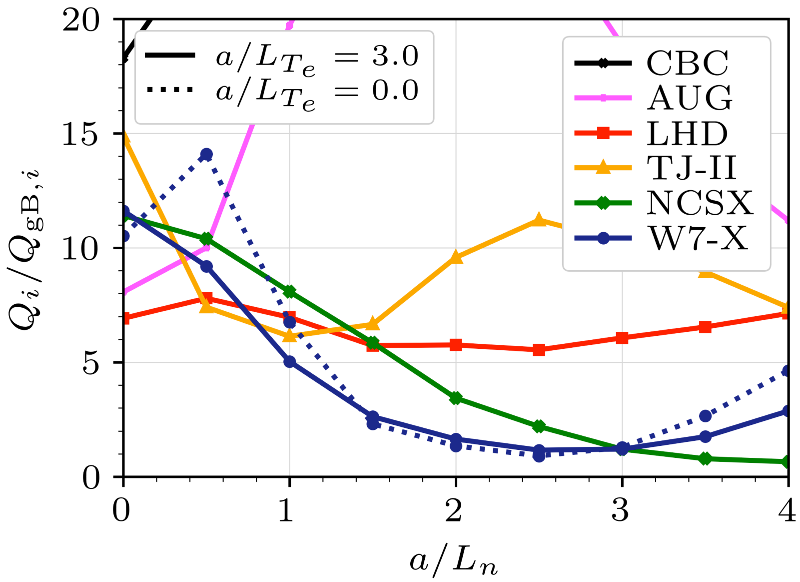

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  - The comparison of the linear growth rate captures to a rather limited extent how nonlinear fluxes compared with each other.
  - **Can we build a quantity based on linear results that predicts how the heat fluxes are going to be?**
  - **Can we design a stellarator with lower turbulence than known stellarators?**

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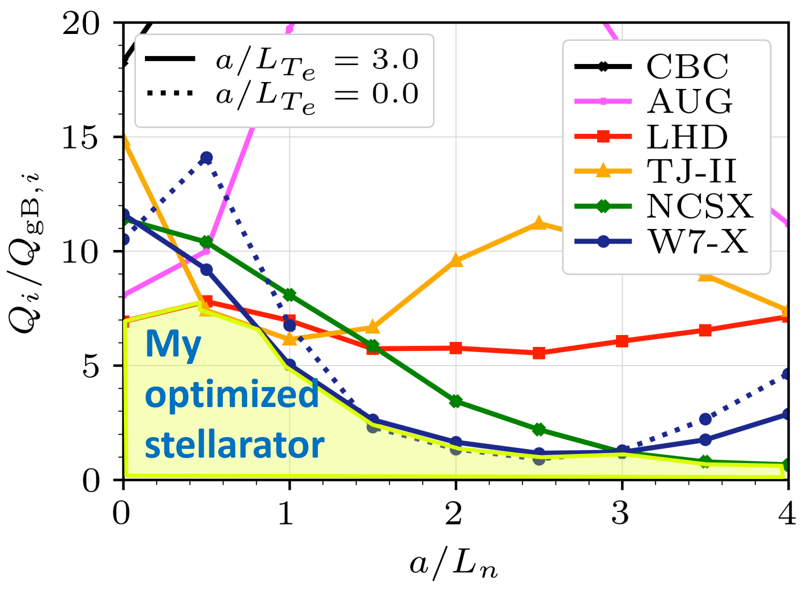

Multi-machine comparison of electrostatic stability and particle transport

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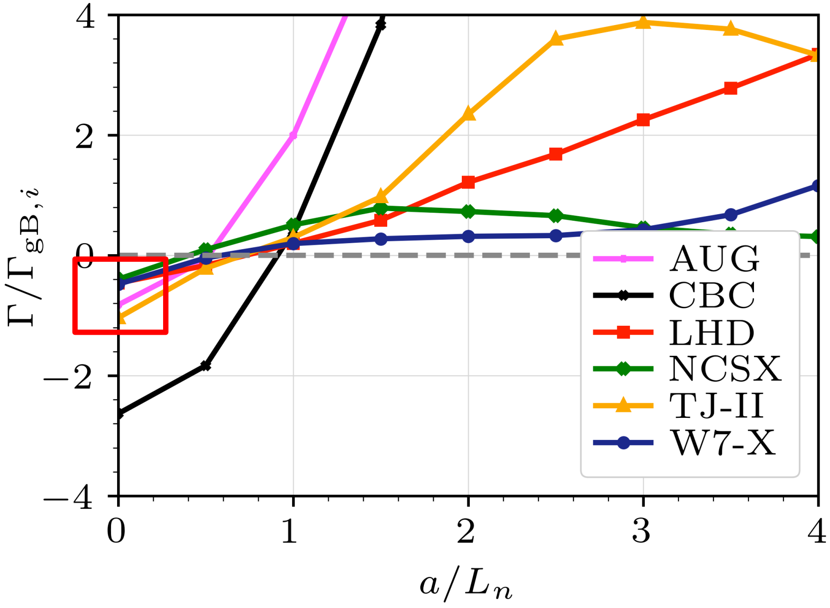
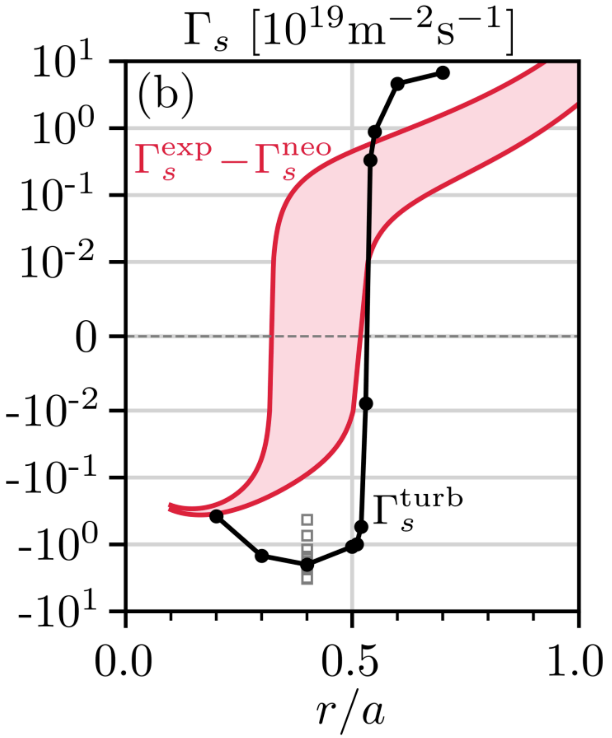


[Thienpondt ISHW´22]

Multi-machine comparison of electrostatic stability and particle transport

- Turbulence driven by finite ***T´ₑ*** and ***T´ᵢ*** **produces a particle pinch in all stellarators analyzed.**

- **Neoclassical theory** predics for stellarators in general and for W7-X in particular [Maassberg PPCF´99, Beidler PPCF'18], **strongly hollow density profiles**. **This turbulent pinch** explains their **absence in experiment.**



[Thienpondt arXiv 2209.04194]

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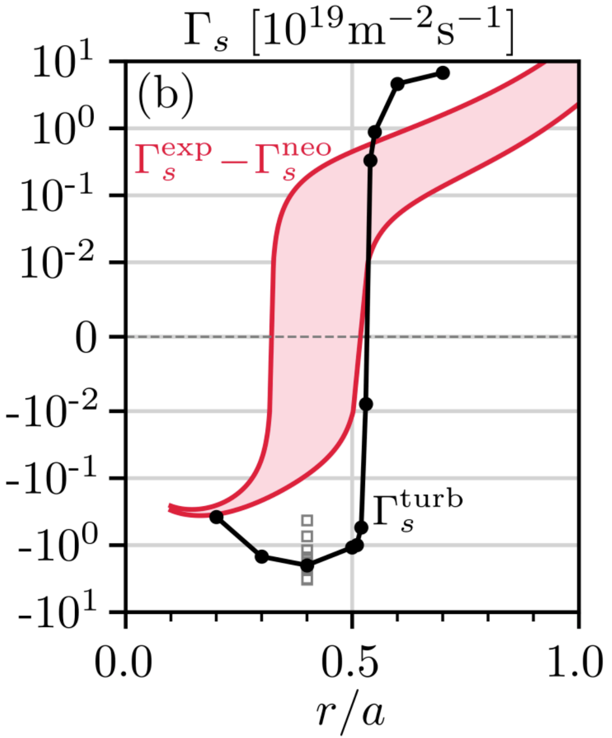
- **Optimization efforts should not overlook particle transport, as this pinch is essential to prevent core density depletion in stellarators.**



[Thienpondt arXiv:2209.04194]

Adjoint methods for gyrokinetic optimization [Acton & Barnes´22]

Motivation:

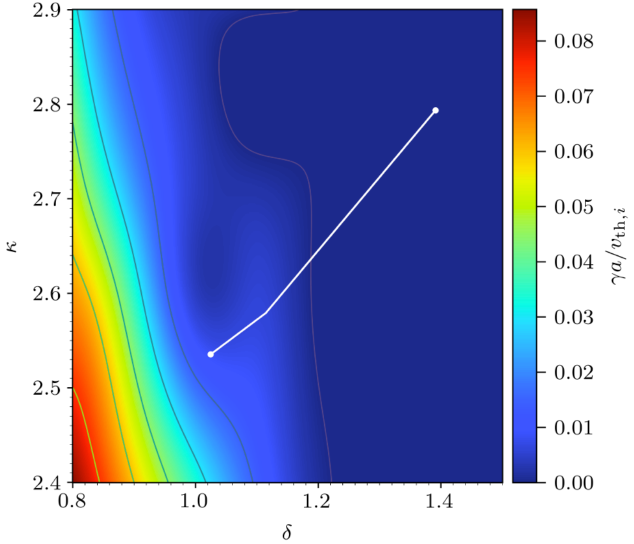
- High-dimensionality of parameter space makes optimization scans computationally expensive.

Aims:

- Develop an **adjoint method for EM gyrokinetics** to facilitate rapid calculation of gradients of the linear growth rate with respect to a (general) set of parameters.
- Implement this into `stella`, and consider the case of optimising with respect to the magnetic geometry, using Miller formalism.

Results:

- Comparison with finite difference scan when varying triangularity (δ) and elongation (κ):



$\gamma(\delta,\kappa)$ for an ion temperature gradient of R_0/L_{Ti}=3.48, increased from R_0/L_{Ti}= 2.42. The first point, in the unstable region, is provided by the previous iteration, at a lower temperature gradient, and a nearby stable geometry is located. The **optimisation path using the Adjoint Method path is indicated in white** (Courtesy of G. Acton and M. Barnes)