



Thrust 4: Stellarators

Meeting on optimization of stellarator turbulent transport

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(also on behalf of Andreas Dinklage and Arturo Alonso)**



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Why this topic for this meeting?



- ❑ W7-X is the first large stellarator designed by optimization of:
 - ❑ MHD equilibrium and stability;
 - ❑ neoclassical transport.

- ❑ **Confirmation of MHD optimization**
 - ❑ *Equilibrium*: sufficiently small bootstrap [Dinklage, Nat. Phys. (2018)] and Pfirsch-Schlüter [Bozhenkov, NF (2020)] currents.
 - ❑ *Stability*: high β not accessible yet.

- ❑ **Confirmation of neoclassical optimization**
 - ❑ Record values of the fusion triple product in stellarator plasmas. Measured plasma profiles could not have been obtained in stellarators lacking neoclassical optimization [Beidler, Nature (2021)].

Demonstration of reduced neoclassical energy transport in Wendelstein 7-X

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Why this topic for this meeting?



- W7-X was designed decades ago. There is room for further optimization beyond W7-X (keeping good MHD and neoclassical properties), in particular with respect to:

- **Fast ion confinement** (at low β , W7-X is not optimized. At high β , fast-ion confinement improves but, probably, not enough):

- Good theoretical understanding, tractable equations.
- Transport codes such as ASCOT, BEAMS3D or ANTS routinely employed.
- Recently developed lighter codes that can be integrated into optimization loops: KNOSOS-MC and SIMPLE.
- More sophisticated fast-ion proxies for optimization suites [Velasco, NF (2021)].

New configurations optimized for fast-ion confinement. For example:

- [Landreman, PRL (2022)], very precise quasisymmetry, excellent fast-ion confinement.
- [Sánchez, ISHW (2022)], quasi-isodynamic configuration, good fast-ion confinement at low β and excellent fast-ion confinement at high β .

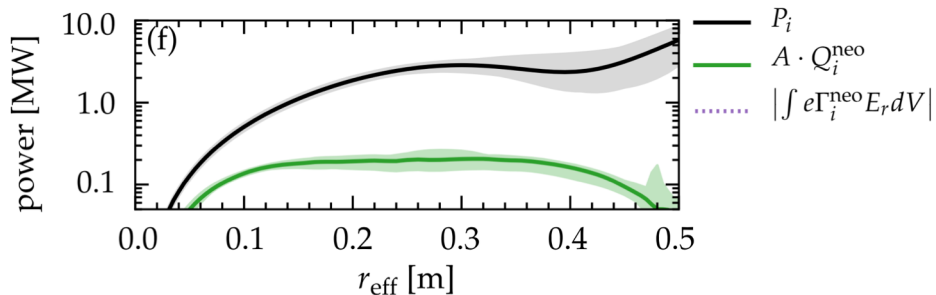
- **Turbulent transport: the big challenge.**

Large turbulent transport in W7-X

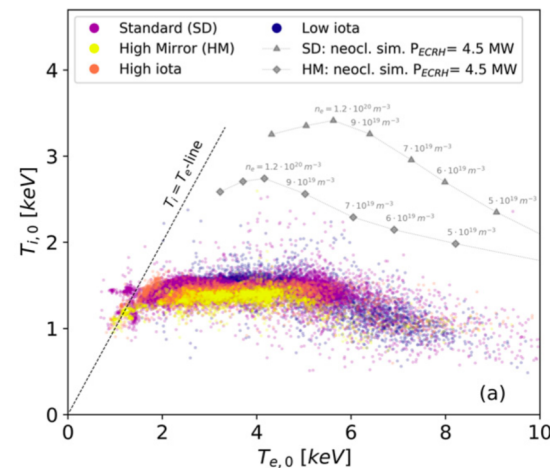


Experiments in the first campaigns have revealed that turbulent transport:

- can dominate over the whole plasma radius;
- prevents access to enhanced performance regimes (T_i clamping).



[Bozhenkov, NF (2020)]



[Beurskens, NF (2021)]

Progress made on gyrokinetic and optimization codes, and increased computational power permit, in principle, addressing the problem of optimizing turbulent transport. **Hence, this meeting.**