Activity on Experimental Transport Model Validation

ISHPDB Documentation Effort

Status Report

presented by Andreas Dinklage

Transport in stellarators/heliotrons consists of anomalous and neoclassical contributions

Full & quantitatively validated models lacking

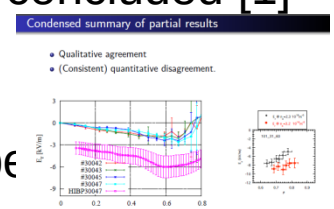
-> perform studies of transport model validation (original scope of ISHPDB/CWGM)

Why **neoclassical** transport? $D_{1/\nu} \sim T^{7/2}$

0) approach: disentangle transport mechanisms to avoid (non-linear) interdependencies

1) understanding of neoclassical transport more mature than anomlous transport in 3d devi

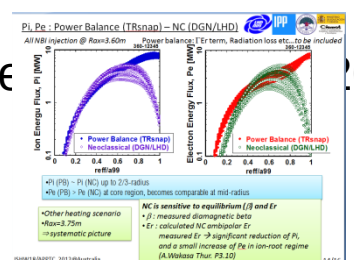
2) benchmarking activity on neoclassical transport has been successfully concluded [1]



Status:

Study on **neoclassical electron heat transport** successfuly done (and be

CERC – intermachine comparison of electron transport done [2]



-> consequent extension + tools exist: **neoclassical ion transport** (agree 20

-> time-line: presentation in ISHW 2012 ✓ and IAEA 2012

-> this meeting: homework for IAEA and discussion of workplan 2013-14

[1] C.D. Beidler *et al.* Nucl. Fusion - Topical Review - submitted (2010)
[2] M. Yokoyama, H. Maaßberg, C. Beidler, *et al.*: Fusion Sci. technol. **50**, 327 (2006); Nucl. Fusion **47**, 1213 (2007).

Ambipolarity condition: E_r

$$-\Gamma_e(r, E_r) + \Gamma_i(r, E_r) + \sum Z_I \Gamma_I(r, E_r) = 0.$$

Neoclassical particle Γ and energy fluxes Q

$$\Gamma_\alpha = -n_\alpha \left\{ D_{11}^\alpha \left(\frac{n'_\alpha}{n_\alpha} - \frac{eZ_\alpha E_r}{T_\alpha} \right) + D_{12}^\alpha \frac{T'_\alpha}{T_\alpha} \right\}$$

$$Q_\alpha = -n_\alpha T_\alpha \left\{ D_{21}^\alpha \left(\frac{n'_\alpha}{n_\alpha} - \frac{eZ_\alpha E_r}{T_\alpha} \right) + D_{22}^\alpha \frac{T'_\alpha}{T_\alpha} \right\}.$$

Electron root conditions: $n_e < 3 \times 10^{-19}$ m^{-3} T_e (keV) >> T_i

Γ_e (E_r=0) >> Γ_i (E_r=0) but $\Gamma_e^{(1)} \sim 0 \rightarrow E_r >> 0$ (CERC)

Ion root conditions: $n_e > 4 \times 10^{19}$ m^{-3} T_e (keV) ~ T_i (**high (ion) heating power, co**

Γ_e (E_r=0) << Γ_i (E_r=0) but $\Gamma_e^{(1)} \sim \Gamma_i \rightarrow E_r << 0$ in gradient region (|E_r|>E

$Q_i \gtrsim Q_e$

low collisionality

neoclassical ion heat transport: need ion heating

measurements: transport coeffiecients [1], kinetic profiles (gradients , E_r , …)

Neoclassical transport theory makes clear predictions (Beidler et al, NF 2011)

→ validation: relevant to 3D transport physics
→ relevant to 3D device operation & scenarios dvlp.

TABLE I: Quantities for the transport validation study.

quantity	
n_e	profile
T_e	profile
T_i	profile
E_r, Φ_p	profile (n, T gradient region)
Z_{eff}	mean value
I_p	profiles?
U_{loop}	
waveforms	
equilibria	
power deposition profiles	
particle sources	

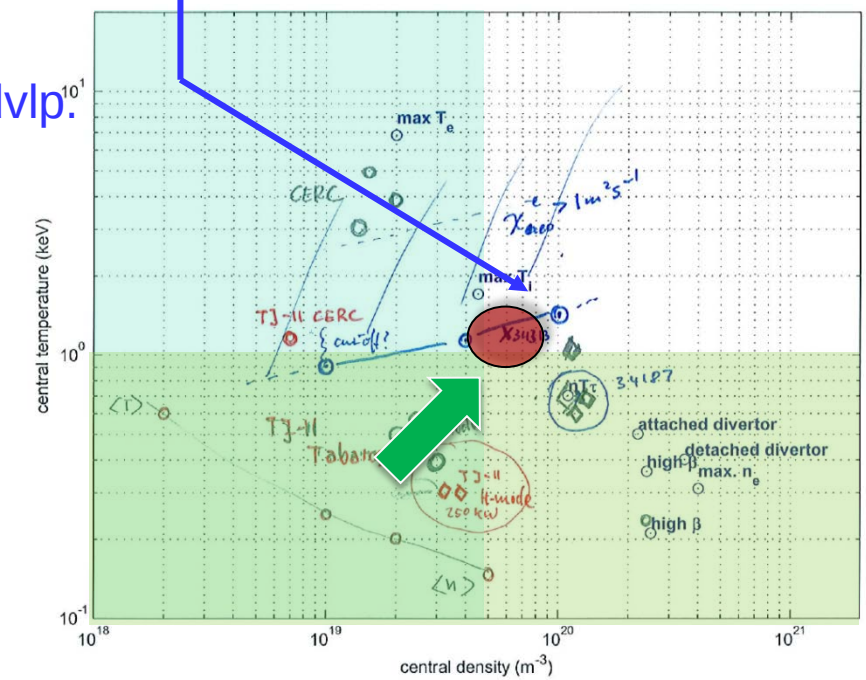


TABLE II: Envisaged parameters for the transport validation study.

quantity	
n_e^0	$> 4 \times 10^{19}\,\mathrm{m}^{-3}$
T_i^0	keV
T_e^0	$\sim T_i^0$

High-performance LHD discharges (ion-root conditions)
W7-AS disharges with prevailing ion transport
TJ-II discharges at high heating power to assess validity of NC theory

→ W7-X operation and validaity of predictive simulations
→ implications (outlook) issues in particle transport, reactor scenarios, extrapolation

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IAEA International Atomic Energy Agency

Contribution ID : 190

EX/P3-14: Inter-Machine Validation Study of Neoclassical Transport Modelling in Medium- to High-Density Stellarator-Heliotron Plasmas

Wednesday 10 Oct 2012 at 08:30 (04h00')

- Paper has been accepted (poster)
- NF paper announced
- Today
  - Revision of material
  - W7-AS, TJ-II, LHD
  - agreement on formats (fluxes vs. χ …)
  - Homework to be done
  - Definition of next steps
  - e.g.
    - extension of documentation
    - particle transport
    - implications for (W7-X, reactor) scenarios

IAEA-INDICO will be reopened for submission of accepted papers on 20 August 2012. The deadline for electronic submission of the full papers as PDF files is 23 September 2012. The IAEA will not accept regular papers submitted after the deadline, and any subsequent submission by email will not be accepted either. The submission deadline for the actual journal paper is 31 December, 2012.