# Review of Master's thesis

# Characterisation of heat fluxes in edge plasma of the COMPASS tokamak in H-mode discharges

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I recommend giving the thesis a: **B (very good)**

**Review**

The thesis examines edge profiles of the COMPASS tokamak. The profiles are evaluated mainly from two important plasma edge diagnostics, the Thomson scattering system for temperature and density measurements in the main scrape-off layer and edge of the confined region and fixed probes in the outer divertor for heat flux estimates. The probe data is compared to IR thermography for selected cases but IR is not used for the data base approach because no systematic data evaluation is presently available. While published data is available for L-mode measurements in COMPASS, the here presented H-mode results are novel and very valuable.

The thesis gives a deep and broad overview of the important underlying Physics principles as well as of recent published works of empirical scaling laws of the power fall-off length in either H-mode, multi-device or multi-regime conditions. A part of this section could be condensed, e.g. the sections about I-mode [1.1.14] and the power balance [1.4.1] are not needed for the reminder of the thesis.

Gyrokinetic simulations are mentioned in the abstract, but no comparison is done further in the thesis. The cited work proposes a widening of the power fall-off length at very high poloidal magnetic field and large major radius. Neither a widening is observed in COMPASS nor should the conditions of [C.S.Chang, NF, 2017] be fulfilled.

The work-flow for the construction of the data base leading to two sub-sets is well explained. The sub-sets are a high-fidelity set with newest and most accurate instruments and a complementary sub-set for enlarging the parameter range. The data sets are governed by an automatic selection process of inter-ELM H-mode time points with both divertor probes and TS signals. A manual check of the data base reduces the included point in the high fidelity data set by about a factor 2. Some explanation on what let the discarded data to be not used would be interesting, e.g. what was the main concern found during the manual check that the automatic search did not filter out?

The work shows a methodical and logical flow, clearly separating the literature work from the novel work performed for this thesis. Further, it has a clear separation between the process of collecting the data, the analysis and the interpretation of the analyzed results.

The thesis shows an uncommon behavior of the SOL power fall-off length compared to the literature. Similarities are found with TCV that is a comparable machine and published very recently an H-mode data set from Thomsen scattering data. Similar to TCV, the COMPASS SOL seems to be sheath limited or at least not clearly in the Spitzer-Harm (conduction) regime. This also complicates the separatrix position check from a local power balance, as done in many tokamaks from the SH heat flux. It is mentioned in the thesis that the real separatrix is likely further out than what the EFIT reconstruction provides. This would also have consequences on the collisionality estimation. The fall-off length estimation is not affected by the exact position due to the exponential fit to the data. It is mentioned in Fig.4.8 that data points are needed for a defined exponential fit that might be affected by a too optimistic error-bar estimation for the density.

It is mentioned that the 'Eich-fit' compared to the exponential fit provides a reasonably similar estimate for the fall-off length, but the peak heat flux is varying. I propose two mechanisms that might significantly affect this, (i) the 'Eich-fit' does not rely on the EFIT strike line location, hence if the location is shifted slightly [in Fig.4.4 it looks like a very small shift towards larger R] the q0,exp [close to qMAX being the maximum heat flux on target] from the exponential fit might be systematically underestimated and (ii) the comparison is not fully accurate, since from the 'Eich-fit' the fitting parameter is q0 [with deconvolved S parameter compared to q0,exp] with a relation of q0 = qMAX *(Lq+1.64S)/ Lq approx. a factor 1.5-2.0 for the given S=0.3..0.6*Lq. The second effect would lead to (exp-Eich)/Eich being in the order of -33% to – 50% being close to the observed difference as shown in Fig. 5.2.

A missing possible explanation for the difference between COMPASS+TCV vs the ITPA multi machine data set is the mechanism for the parallel heat flux, both TCV and COMPASS show that they are not in good agreement with SH conduction, which might change the behavior of the transport significantly.

I was missing an attempt to estimate the parallel heat flux from upstream temperature and density data using the SH assumptions, FL assumptions and the combination of the two [ 1/q|| = 1/qSH + 1/qFL]. This might help in localizing the separatrix [q||*Lq == Psol] with Psol being the power towards the outer divertor. This would also be a quantity to compare the qExB to in section 6.3 in addition to the measured heat flux from divertor probes.

**Conclusion**

The thesis is well written, with an understandable and sufficient level of English. In some places articles are missing but overall this is not hindering the readability. The thesis is a complete document, showing the understanding of the material as well as novel experimental findings for which possible explanations are provided.

**Questions for the defense**

- How well is the radially constant sheath heat transmission factor justified for the power fall-off length estimate from fixed probes?
- Why is the collisionality in the scrape-off layer rather constant? In typical SOL conditions of other tokamaks the temperature decays significantly faster than the density, leaving high collisionality in the far-SOL.
- How well does the EFIT reconstruction fit for the strike line position? In Fig.4.4 the agreement looks reasonable, is this the case for the complete data set?

13.08.2021, Garching — Dr. Michael Faitsch

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