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INSTITUTO DE PLASMAS
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Evaluation of the thesis

“Enhanced Plasma Confinement in Tokamaks with Focus on the Turbulence-Flow Interaction”

This report concerns the evaluation of the thesis entitled “Enhanced plasma confinement in tokamaks with focus on the turbulence-flow Interaction”, submitted by Mr. Ondrej Grover to obtain the Ph.D in the Czech Technical University in Prague.

Background

The work developed by the candidate is part of an effort in science and technology to realize nuclear fusion as a limitless clean energy source. Achieving a high energy confinement associated with attractive conditions for power exhaust is seen as one of the most critical issues determining the viability of a fusion reactor. Thus, it is crucially important to understand the transport processes in the edge plasma associated with turbulence and its interaction with the flows. The work carried out by Mr. Ondrej Grover has been focused in the area of turbulence at the plasma edge and physics of the scrape-off layer and divertor that is highly relevant.

The main focus of the thesis is to contribute to a better understanding of the L-H transition and improved confinement regimes such as the I-mode. The study of limit cycle oscillations led to the development of a first-principles-based model to predict their frequency using data from four tokamaks (JET, ASDEX Upgrade, COMPASS, Globus-M). The work was performed on different devices in multidisciplinary teams and involves international collaborative programs proving the international and integrated approach of the activities.

The Ph.D thesis is well structured, easy to read and revealing a deep understanding of the edge turbulence mechanisms. The introductory chapters (*Introduction, Chapters 1 and 2*) give an overview of the enhanced confinement in tokamaks and the experimental and theoretical analysis methods used in the thesis. These chapters, in fact the entire thesis, is written in a clear and concise style. The goals of the thesis could have been described in more detail. Often the objectives are presented after more background is given, so that the motivation for the proposed goals can be clearly presented. Would be beneficial to include a more detailed description on basic tokamak physics, diagnostics and analysis methods used in the work carried out by the candidate. In particular, would be useful to present a more comprehensive description of the approximations used to

estimate the different physics quantities from electrical probe data. For instance, the following points could have been explained: What pins were used to estimate the Reynolds stress and energy transfer? As BPPs do not measure exactly the plasma potential, what is the effect of the temperature fluctuations in the estimated quantities? What is the possible influence of the toroidal flow and its fluctuations in the measurements?

The main part of the document is *Chapter 3*, presenting the results obtained in the scope of the thesis. It includes studies associated with limit cycle oscillations on COMPASS reported in section 3.1, mostly in the form of a published paper. The subsequent development of an extended model for the limit cycle oscillations in different tokamaks is presented in section 3.2, again in the form of a paper submitted for publication. Section 3.3 presents the generalization of a model for the separatrix operational space in ASDEX Upgrade, while section 3.4 presents I-mode studies also in ASDEX Upgrade. Finally, the Conclusions and Outlook are presented.

Value and significance of the Ph.D thesis

In terms of value and significance the results obtained by Mr. Ondrej Grover are of great relevance for a better understanding of improved confinement regimes. He has implemented sophisticated analysis methods and has obtained significant contributions related to the physics of the limit cycle oscillations, the modelling of the separatrix operational space and has performed attempts to achieve an I-mode in favorable ∇B drift direction. Therefore, the goals proposed for this thesis were clearly achieved.

Recommendation

My opinion is that the research activity of Mr. Ondrej Grover described in this thesis is highly valuable, timely and important as a contribution in the path towards the understanding of improved confinement regimes. The research is focused mostly on turbulence-flow interaction, revealing a deep understanding of a broad range of the topics. Mr. Ondrej Grover is well respected in his field and is a great ambassador for the university. In spite of the remarks related to the introductory chapters, the research presented is solid and the chapter reporting on the core work is clear and well readable. Overall, my judgment of the thesis is very positive and I recommend to accept the thesis and to award the Ph.D degree.

Carlos Garcia Silva

Lisbon, 27th September 2021