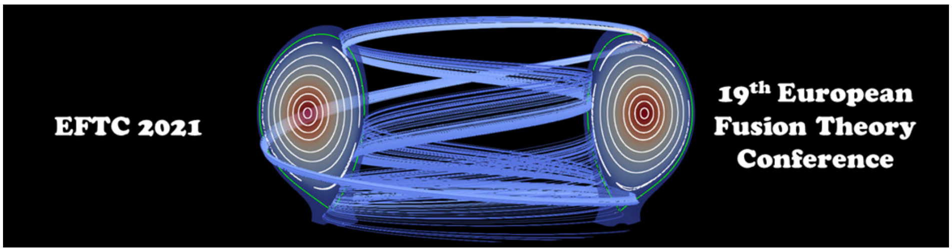

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Emergent signature of a global scaling of heat transport in fusion plasmas

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In order to achieve sustainable confinement in fusion plasmas, it is crucial to understand and mitigate all transport mechanisms. In recent years observations show that there is a strong evidence that the overall transport of heat and particles is to a large part caused by intermittency (or bursty events) related to coherent structures. In this work a novel approach where a global heat flux model based on a fractional derivative of plasma pressure is proposed for the heat transport in fusion plasmas. A simplified transport coefficient is assumed to capture all physical properties of the plasma, including neoclassical and anomalous transport. This assumption yields an exponent of the main derivative to be fractional instead of integer. The fractional degree of the heat transport is defined through the power balance analysis. In the proposed fractional model, a single constant fractionality index, α, is used as the dominant global scale dependence of the transport which is modified as compared to a diffusive model where $\alpha=2$. Our aim with this work is to find a reduced (i.e., with the least number of parameters involved) transport model that can predict most plasmas, therefore ignoring the detail nature and the classifications of the transport processes involved, and bundle their average (time/radial) effect into one constant parameter, α. The method was used to study the heat transport in a selected set of JET plasmas, including C-Wall and ITER like Wall, L-mode, H-mode, with many different heating and fueling schemes from a wide range of experimental programs and plasmas with and without ELMs and various MHD modes active. The average fractional degree of the heat flux over the dataset was found as α ˜ 0.8. Note that the model will instantly yield necessary profile evolutions and could thus be used as a feedback control of the plasma stability and control in real time by predicting profiles and providing a tool to detect and perhaps prevent or mitigate destructive transport events. It should be noted, that in some cases there is a wider range of α parameters over the database because these plasmas are in essence very different with one another on many factors such as the NBI or ICRH input power, fueling scheme, ELM control, etc. What we are observing however, is that a significant number of these plasmas fall into a similar range for α parameter specially as the input power is increased yielding a transport model with predictive power in a wide parameter regime. Finally, we would like to make a note that this study is the first of its kind and its findings are expected to encourage further discussion on the validity and the mathematical limitations of our current models to address global properties of transport in fusion plasmas.

Primary authors: Dr KIM, Hyun-Tae (EUROfusion Programme Management Unit); ANDERSON, Johan; Dr ROMANELLI, Michele (Culham Centre for Fusion Energy); Dr MORADI, Sara (IPP)

Presenter: ANDERSON, Johan

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