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P2.1080 Study of heat transport in magnetic confinement devices using Transfer Entropy

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Our recent studies [1-3] have shown that heat transport in magnetic confinement devices (the stellarators TJ-II and W7-X) is not a smooth and continuous (diffusive) process, but involves mini-transport barriers associated with low-order rational surfaces and rapid non-local radial 'jumps'. This remarkable finding sheds a new light on the nature of anomalous transport and potentially provides insight into a long-standing conundrum of the physics of magnetically confined plasmas: power degradation or the enhancement of the radial transport coefficient as heating power is increased, a phenomenon encountered in all magnetic confinement devices, yet still not fully understood. In this work, we summarize our findings so far, and complement these by adding new, recent results obtained at the JET tokamak. The latter show that heat transport in tokamaks is also affected by the presence of the mentioned mini-transport barriers. These results are obtained using a relatively novel analysis technique (transfer entropy) that has been found to be extremely sensitive to the anomalous (non-local) transport component. We carefully verify the interpretation of the transfer entropy results by deducing effective diffusivities and comparing these to traditional results. We analyze transport as a function of different heating power levels and different magnetic geometry. The stellarator results are modelled qualitatively using a resistive MHD model, reproducing the salient features of the experimental observations. A main characteristic of this model is that it incorporates interactions between turbulence and the magnetic geometry, thus providing a route to understanding transport effects associated with loworder rational surfaces, such as those observed. Finally, the transfer entropy results are reinterpreted based on ideas from Continuous Time Random Walks, offering an interesting alternative view of heat transport, superseding the usual description in terms of diffusivities.

[1] B. van Milligen, J. Nicolau, L. García et al. Nucl. Fusion, 57(5):056028, 2017.
[2] B. van Milligen, B. Carreras, C. Hidalgo, et al. Phys. Plasmas, 25:062503, 2018.
[3] B. van Milligen, U. Hoefel, J. Nicolau, et al. Nucl. Fusion, 58(7):076002, 2018.

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