Multi-messenger measurement of transport properties of turbulent and magnetised plasmas

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Experiments conducted at the Laboratory for Laser Energetics' (LLE) OMEGA and Lawrence Livermore National Laboratory's National Ignition Facility (NIF) have replicated the micro-physics of galaxy clusters, revealing a breakdown of Spitzer's heat conduction theory in highly magnetized, turbulent, and weakly collisional plasmas [1, 2].

Using line-integrated X-ray emission analysis these experiments have provided compelling evidence that the presence of turbulent-dynamo-amplified magnetic fields significantly suppresses heat conduction, a phenomenon not accounted for by Spitzer's theory. Whilst such analysis has provided valuable insights into the overall heat transport behaviour, a deeper understanding of the underlying processes is gained via small-scale direct probing techniques such as Thomson scattering [3].

Statistical fitting of the time-resolved ion-acoustic and electron plasma wave scattering provides a detailed understanding of both the plasma conditions and in turn the thermal diffusivity. This information can be combined with the X-ray emission data to improve the overall understanding of the turbulent plasma behaviour.

[1] Meinecke *et al.*, Sci. Adv., 8, eabj6799 (2022)

[2] Tzeferacos *et al.*, Nature Comm., 9, 591 (2018)

[3] Bott *et al.*, PNAS, 118, e2015729118 (2021)