8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Synthetic Doppler-backscattering diagnostic based on reduced models of plasma-wave interactions: recent progress and next steps

Valerian H. Hall-Chen[1], K. Barada[2], V.P. Bui[1], Y. Chow[1], S. Chowdhury[2], N.A. Crocker[2], J. Damba[2], K.R. Fong[1,3], M. Giacomin[4], P. Hill[4], J.C. Hillesheim[5], Y.H.M. Liang[1], T. Macwan[2], L.B.S. Marsh[1], C.A. Michael[2], R.J.H. Ng[1], R. Otin[6], F.I. Parra[7], B. Patel[6], E. Poli[8], Q.T. Pratt[2], T.L. Rhodes[2], J. Ruiz Ruiz[9], P. Shi[10], Z.K.I. Tan[1,3], N.Q.X. Teo[1,11], J.W. Tumbokon[1,3], J. Wang[1], X. Wang[1], T. Xing[1], A.K. Yeoh[1,9]

[1]IHPC, Agency for Science, Technology and Research (A*STAR), Singapore
[2]UCLA [3]NUS [4]York [5]CFS [6]UKAEA [7]PPPL [8]MPI [9]Oxford [10]ASIPP [11]NTU

e-mail (speaker): valerian_hall-chen@ihpc.a-star.edu.sg

Turbulent transport limits the performance of modern fusion devices. Understanding this turbulence is key to designing and optimising the next generation of fusion energy systems. However, measuring turbulent fluctuations is difficult due to the spatial and temporal resolutions required. Doppler backscattering (DBS) is one of the few diagnostics capable of measuring turbulent density fluctuations. Direct quantitative comparison between such measurements and gyrokinetic simulations of the same is challenging. Such comparison requires a model of plasma-wave interactions, acting as a synthetic diagnostic. Full-wave synthetic diagnostics are computationally intensive while ray tracing is unable to quantitatively account for instrumentation effects such as beam focusing and mismatch attenuation.

In this talk, we present an overview of our synthetic DBS diagnostic, which is based on beam tracing and the reciprocity theorem, and implemented in the Scotty code platform. Scotty is capable of predictively and quantitatively calculating DBS instrumentation effects in tokamak and stellarator geometries, and runs in under ten seconds. We will summarise our recent work on the validation of Scotty on DIII-D and MAST-U, followed by its use as a bridge between gyrokinetic simulations and DBS in these two tokamaks. We will then cross-compare Scotty with beam-tracing code TORBEAM and finite-element frequency-domain full-wave code ERMES. Finally, we will show preliminary comparisons of beam tracing with full-wave simulations.

Acknowledgements: This work was funded by A*STAR (Green Seed Fund C231718014, YIRG M23M7c0127, and a SERC Central Research Fund). This material is also based upon work supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences, using the DIII-D National Fusion Facility, a DOE Office of Science user facility, under Awards DEFC02-04ER54698 and DE-SC0019352. This work was also in part supported by a grant from the Engineering and Physical Sciences Research Council (EPSRC) [EP/R034737/1].