Modelling the effect of the misalignment of the probe beam and the magnetic field in Doppler backscattering measurements

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The Doppler Backscattering (DBS) microwave diagnostic enables the non-perturbative characterisation of density fluctuations ($1 \lesssim k_\perp \rho_i \lesssim 10$) and flows, both at the edge and the core of the plasma. However, the use of DBS in spherical tokamaks is complicated since the magnetic pitch angle is large (up to 35°, compared to 15° in standard tokamaks like JET). Moreover the pitch angle varies both spatially and temporally. Consequently, the DBS probe beam and the magnetic field may not be normal to each other. This misalignment, which affects the backscattered signal, can be empirically optimised with 2D beam steering [1].

We used the beam tracing code Torbeam [2] to determine where the probe beam is scattered. The code also enabled the beam width and curvature to be determined. Using this information, we have developed a model to determine the backscattered power and its dependence on the mismatch angle, thereby accounting for the misalignment of DBS measurements. The results are compared to scans of the toroidal launch angle from MAST data. With insight from our model, we also assessed the measurement capabilities for the planned MAST-U DBS system.

Our model avoids having to perform empirically optimisation (for example, by scanning different toroidal launch angles for a given poloidal launch angle). This could be particularly useful for DBS implementations where beam steering is limited.

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