A model based approach for filtering magnetic pitch angle obtained by MSE

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One of the challenges in fusion research is the optimisation of the operation regime of current and future tokamaks. The safety- or q-factor is an important quantity for plasma stability and performance, however no direct measurement is available. It is usually calculated by equilibrium reconstruction codes constrained by magnetic pitch angle information obtained from the motional stark effect diagnostic (short MSE). Even though this is now considered a routine diagnostic with over 25 years of experience, it is often plagued by its difficult calibration and its susceptibility to systematic errors.

To cope with these problems an observer based approach to filter the MSE data is proposed. A state observer merges measurements with a dynamic model of the system and thus does not only compute a simple inversion of the measurement to reconstruct the state, but takes the underlying physics into account. As the underlying physics model RAPTOR \textsuperscript{2} (RAPid TranspORT simulator), a real-time capable, 1 dimensional transport simulator which solves the poloidal flux diffusion equation is used. With this the MSE data is filtered by an extended Kalman filter (EKF), which, by combining state estimates from the physics model with the measurement and their history, can result in better estimates of the true state of the system. This can significantly improve the quality of the pitch angle measurement, especially if it is evidently erroneous and in contradiction with the current diffusion model or if a scenario is run where it is known that MSE provides unreliable data.

In this first investigation we present how noise contaminated pitch angles obtained from MSE in combination with an EKF can be used to provide accurate pitch angle information to a Grad-Shafranov equilibrium solver. The successfully reconstructed equilibrium can in turn be used to update the predictive model to increase the accuracy of the state reconstruction.

References: