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Interplay of MHD instability and impurity transport during ECRH heating on HL-2A tokamak

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Abstract. In the heating scenario of HL-2A experiments, saturated internal kink modes (m/n=1/1 and its harmonics) have been observed and studied by a combined use of spectrum analysis of magnetic signals and tomography of soft X-ray (SXR) data. These MHD modes are found to locate at the $q=1$ surface ($r_{q=1} \approx a/3$) and interact with the energetic particles produced by heating, appearing as either intermittent bursts or a long-lasting form. They, therefore, can often lead to a significant change in local parameters e.g. electron temperature and transport. In recent experiments of ECRH heating with different deposition positions (inner-deposited and outer-deposited, delimited by the radial position of sawtooth inversion, $r_{inv} \approx a/5$), after Aluminum trace impurity injection by laser blow-off, the oscillations due to saturated internal kink modes are also observed in-between sawtooth crashes. In addition, it is worth noting that the outer deposited heating produces a rather peaked SXR emission distribution in comparison with the inner deposited case, while the latter is featured by a hollow and asymmetric distribution (Fig. *1*). Since the emissivity after subtracting the background contributions prior to the injection is mostly attributed to the impurity, the hollowness can be assumed to be induced by an outward convection of the impurity from plasma center to the place close to $q=1$ surface where MHD instabilities appear. In this work, we aim to develop a method to decouple the electron temperature effects from SXR emission based on an emission model, $n_e n_A L_A^{SXR}(T_e, n_e)$, where L_A^{SXR} is a so-called radiation loss parameter and can be predicted from the ADAS database, so that the SXR reconstructions can be used to estimate the impurity transport coefficients, focusing on the region within $q=1$ surface where there exist an influence of MHD modes on impurity transport. The analysis results will also be benchmarked with the diffusion and convection coefficients obtained by a 1-D impurity transport code STRAHL.

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[2] Z.Y. Cui et al, "Enhancement of edge impurity transport with ECRH in the HL-2A tokamak," *Nucl. Fusion*, vol. 53, p. 093001, 2013.

[3] M Sertoli, "Modification of impurity transport in the presence of saturated (m,n) = (1,1) MHD activity at ASDEX Upgrade," *Plasma Phys. Control. Fusion*, vol. 57, p. 075004, 2015.

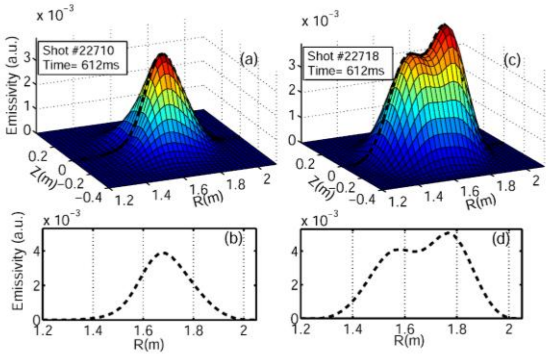

Fig. 1: The typical SXR emission as a reflection of trace impurity profiles, from the outer and inner depositions, respectively. (a) A peaked emission distribution and its interception at Z=0m (b); (b) A hollow and asymmetric emission distribution and its interception at Z=0m (d).