Upgrade of ECRH launcher for NTM real-time control on HL-2A tokamak

Shaodong Song\textsuperscript{a,*}, Mei Huang\textsuperscript{a}, Jiruo Ye\textsuperscript{a}, Gangyu Chen\textsuperscript{a}, Chao Wang\textsuperscript{a}, Longwen Yan\textsuperscript{a}, Xiaoquan Ji\textsuperscript{a}, Fan Xia\textsuperscript{a}, Yuan Xu\textsuperscript{a}, Shaoyong Chen\textsuperscript{b}, Changjian Tang\textsuperscript{b}, Tieliu Zheng\textsuperscript{a}, He Wang\textsuperscript{a}, Jieqiong Wang\textsuperscript{a}, Kun Feng\textsuperscript{a}, Zihua Kang\textsuperscript{a}, Mingwei Wang\textsuperscript{a}, Feng Zhang\textsuperscript{a}, Jun Rao\textsuperscript{a}, Bo Lu\textsuperscript{a}, Min Jiang\textsuperscript{a}, Zengchen Yang\textsuperscript{a}, Xianming Song\textsuperscript{a}, Zhongbing Shi\textsuperscript{a}, Yi Liu\textsuperscript{a}, Qingwei Yang\textsuperscript{a}, Min Xu\textsuperscript{a}, Xuru Duan\textsuperscript{a}, Yong Liu\textsuperscript{a}

\textsuperscript{a} Southwestern Institute of Physics, P. O. Box 432, Chengdu, Sichuan 610041, China
\textsuperscript{b} College of Physical Science and Technology, Sichuan University, Chengdu, Sichuan 610065, China

\textbf{ARTICLE INFO}

\textbf{Keywords}
ECRH
EC launcher
NTMs
Real-time control

\textbf{ABSTRACT}

Electron cyclotron resonance heating and current drive (ECRH/ECCD) are deemed to be one of the best option to control the neoclassical tearing modes (NTMs), which are potential danger for steady state operation in fusion reactors. Recently, one of the two ECRH equatorial launchers on HL-2A tokamak has been upgraded to satisfy the real-time control requirements. The upgrade of the rotation and driving mechanism accelerates the tuning speed of poloidal injection angle of EC beam significantly, which permits the modification of the EC power deposition position in real time. Analyses on the beam injection angles and wave power losses, together with calibration results on test bed indicate that the new launcher has a good launching performance. The upgraded No. 2 ECRH launcher was successfully applied in the first proof-of-principle experiment for NTM real-time control, in which within 250 ms suppression of the classical tearing modes (CTMs) by ECRH/ECCD was realized for the first time on HL-2A.