Contribution ID: **49** Type: **Poster**

Suppression of Toroidal Alfvén Eigenmodes by the Electron Cyclotron Current Drive in KSTAR Plasmas

Wednesday, 4 September 2019 15:15 (15 minutes)

Advanced operation scenarios such as high poloidal beta (β_P) or high q_{min} and so on are the promising concepts to achieve the steady-state high beta fusion plasmas. Those scenarios, however, are prone to excitation of the strong Alfvénic mode activities causing fast-ion transport and losses due to its fast-ion pressure gradient and broad current profile as the heating power and the confinement increase. Recent experimental studies on KSTAR under the advanced scenario attempts have shown that the electron cyclotron current drive (ECCD) is able to suppress the beam-ion driven toroidal Alfvén eigenmodes (TAEs) successfully for over several tens of confinement time. Experiments have been performed by scanning the injection angle of the electron-cyclotron (EC) wave. The off-axis ECCD is found to be effective to mitigate or suppress the TAEs, while the on-axis or far off-axis ECCD has shown no visible effect. Intermediate off-axis co-current directional ECCD lowers the central safety factor slightly and tilts the central q-profile shape so that the Alfvén continuum gap (NOVA calculations) is elevated and the gap width becomes slightly narrow in the core region, hence the TAEs at the core region become damping. In addition, rise of plasma beta at the transition and suppression phase contributes to TAE stabilization, too. While the TAEs are suppressed, neutron emission rate and total stored energy increase by approximately 50% and 25%, respectively. Fast-ion transport estimated by TRANSP calculations approaches to the classical level during the TAE suppression period. Substantial reduction in neutron deficit and fast-ion loss is also observed. Enhancement of fast-ion confinement by suppressing the TAEs leads to increase of non-inductive current fraction, indicated by loop-voltage reduction, and will be beneficial to the sustainment of the long-pulse high-performance discharges.

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Session Classification: Poster

Track Classification: Control of Energetic Particle Confinement