Validation of on- and off-axis neutral beam current drive against experiment in DIII-D

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Abstract

Neutral beam current drive (NBCD) experiments in DIII-D using vertically shifted plasmas to move the current drive away from the axis have clearly demonstrated robust off-axis NBCD. Time-dependent measurements of magnetic field pitch angles by the motional Stark effect diagnostic are used to obtain the evolution of the poloidal magnetic flux, which indicates a broad off-axis NBCD profile with a peak at about half the plasma minor radius. In most cases, the measured off-axis NBCD profile is consistent with calculations using an orbit-following Monte-Carlo code for the beam ion slowing down including finite-orbit effects provided there is no large-scale MHD activity such as Alfvén eigenmodes modes or sawteeth. An alternative analysis method shows good agreement between the measured pitch angles and those from simulations using transport-equilibrium codes. Two-dimensional image of Doppler-shifted fast ion D_α light emitted by neutralized energetic ions shows clear evidence for a hollow profile of beam ion density, consistent with classical beam ion slowing down. The magnitude of off-axis NBCD is sensitive to the alignment of the beam injection relative to the helical pitch of the magnetic field lines. If the signs of B and I yield the proper helicity, both measurement and calculation indicate that the efficiency is as good as on-axis NBCD because the increased fraction of trapped electrons reduces the electron shielding of the injected ion current, in contrast with electron current drive schemes where the trapping of electrons degrades the efficiency. The measured off-axis NBCD increases

approximately linearly with the injection power, although a modest amount of fast ion diffusion is needed to explain an observed difference in the NBCD profile between the measurement and the calculation at high injection power.

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