Cold pulse and rotation reversals with turbulence spreading and residual stress

Hariri, F.; Naulin, Volker; Rasmussen, Jens Juul

Publication date:
2016

Document Version
Peer reviewed version

21st EU-US Transport Task Force Meeting, Leysin, 5-8 September 2016

Cold pulse and rotation reversals with turbulence spreading and residual stress

F. Hariri[1], V. Naulin[2], J. Juul Rasmussen[2], G. S. Xu[3], N. Yan[3]

[1]École Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC), CH-1015 Lausanne, Switzerland

[2] Technical University of Denmark (DTU), Department of Physics, DK-2800 Kgs. Lyngby, Denmark

[3] Institute of Plasma Physics, Chinese Academy of Sciences, ASIPP, Hefei, China

Corresponding author: Volker Naulin Email: vona@fysik.dtu.dk

In low density L-mode plasmas nonlocal phenomena as cold pulse polarity reversal and fast cold pulse propagation are observed since long. Additionally the same plasmas show internal rotation reversals in the absence of sources[1]. Here we propose transport modeling based on inclusion of turbulence spreading and residual stresses[1,2,3]. We show internal rotation reversals and polarity reversal of cold pulses, with a clear indication of nonlocal transport effects due to fast spreading in the turbulence intensity field. The effects of turbulence spreading and residual stress are calculated from the gradient of the turbulence intensity. In the model presented in this paper, the flux is carried by the turbulence intensity field, which in itself is subject to radial transport effects. The pulse polarity inversion as well as the rotation profile reversal positions is close to the radial location of the stable/unstable transition. Both effects have no direct explanation within the framework of classical transport modeling, where the fluxes are related directly to the linear growth rates, the turbulence intensity profile is not considered and the corresponding residual stress is absent. Our simulations are in qualitative agreement with measurements from ohmic plasmas. Rotation reversal at a finite radius is found in situations of linear Ohmic confinement (LOC) and is not observed in saturated Ohmic confinement (SOC), which we identify as situations where the plasma is nearly everywhere unstable. As an additional and new effect, the model predicts a perturbation of the velocity profile following a cold pulse from the edge. This potentially allows direct experimental confirmation of the existence of residual stress caused by turbulence intensity profiles as well as the fundamental ideas of transport modeling presented here.

[1] JE Rice, Chi Gao, ML Reinke, PH Diamond, NT Howard, HJ Sun, Istvan Cziegler, AE Hubbard, YA Podpaly, WL Rowan, et al. Nonlocal heat transport, rotation reversals and up/down impurity density asymmetries in Alcator C-Mod ohmic L-mode plasmas. Nuclear Fusion, 53(3):033004, 2013.

[2] TS Hahm, PH Diamond, Z Lin, K Itoh, and SI Itoh. Turbulence spreading into the linearly stable zone and transport scaling. Plasma Physics and Controlled Fusion, 46(5A):A323, 2004.

[2] V Naulin, AH Nielsen, and J Juul Rasmussen. Turbulence spreading, anomalous transport, and pinch effect. Physics of Plasmas, 12(12):122306, 2005.

[3] F. Hariri, V. Naulin, J. Juul Rasmussen, G. S. Xu, N. Yan, Cold pulse and rotation reversals with turbulence spreading and residual stress, Physics of Plasmas, in press, 2016

Preference Poster

x Oral in session xx