IOP Publishing | International Atomic Energy Agency Nuclear Fusion

Nucl. Fusion **58** (2018) 056018 (17pp) https://doi.org/10.1088/1741-4326/aab2c8

Edge transport and mode structure of a QCM-like fluctuation driven by the Shoelace antenna

T. Golfinopoulos[a], B. LaBombard, D. Brunner, J.L. Terry, S.G. Baek, P. Ennever, E. Edlund, W. Han, W.M. Burke, S.M. Wolfe, J.H. Irby, J.W. Hughes, E.W. Fitzgerald, R.S. Granetz, M.J. Greenwald, R. Leccacorvi, E.S. Marmar, S.Z. Pierson, M. Porkolab, R.F. Vieira, S.J. Wukitch and The Alcator C-Mod Team

Plasma Science and Fusion Center, Massachusetts Institute of Technology, Cambridge, MA 02139, United States of America

E-mail: golfit@mit.edu

Received 30 November 2017, revised 31 January 2018
Accepted for publication 28 February 2018
Published 21 March 2018

Abstract

The Shoelace antenna was built to drive edge fluctuations in the Alcator C-Mod tokamak, matching the wavenumber ($k_\perp \approx 1.5$ cm^{-1}) and frequency ($30 \lesssim f \lesssim 200$ kHz) of the quasi-coherent mode (QCM), which is responsible for regulating transport across the plasma boundary in the steady-state, ELM-free Enhanced D_α (EDA) H-mode. Initial experiments in 2012 demonstrated that the antenna drove a resonant response in the edge plasma in steady-state EDA and transient, non-ELMy H-modes, but transport measurements were unavailable. In 2016, the Shoelace antenna was relocated to enable direct measurements of driven transport by a reciprocating Mirror Langmuir Probe, while also making available gas puff imaging and reflectometer data to provide additional radial localization of the driven fluctuation. This new data suggests a ~4 mm-wide mode layer centered on or just outside the separatrix. Fluctuations coherent with the antenna produced a radial electron flux with $\Gamma_e/n_e \sim 4$ m s^{-1} in EDA H-mode, smaller than but comparable to the QCM level. But in transient ELM-free H-mode, Γ_e/n_e was an order of magnitude smaller, and driven fluctuations reduced by a factor of $\gtrsim 3$. The driven mode is quantitatively similar to the intrinsic QCM across measured spectral quantities, except that it is more coherent and weaker. This work informs the prospect of achieving control of edge transport by direct coupling to edge modes, as well as the use of such active coupling for diagnostic purposes.

Keywords: fusion, tokamak, shoelace antenna, edge transport, edge fluctuations, Alcator C-Mod, quasi-coherent mode

(Some figures may appear in colour only in the online journal)

1. Introduction

The practical realization of fusion energy within the tokamak framework depends, in part, upon the identification of viable steady-state, reactor-relevant, high-performance operational regimes. A common feature between such regimes is the presence of a benign, continuous fluctuation in the plasma edge [1].

Examples of such continuous fluctuations include the weakly coherent mode (WCM) associated with the I-mode regime [2, 3], the Edge harmonic oscillation of the quiescent H-mode [4, 5], the Low- and high-frequency quasi-coherent modes of the high recycling steady regime [6, 7], and the quasi-coherent mode (QCM) of the enhanced D_α (EDA) H-mode [8–14]. These fluctuations sustain high-performance regimes by making the edge permeable to impurities without significantly degrading energy confinement. While edge localized

[a] Author to whom any correspondence should be addressed.