ID: 2781

EDGE MAGNETIC ISLANDS AND ITS APPLICATION TO THE DEVELOPMENT OF ADVANCED DIVERTOR CONFIGURATION ON THE J-TEXT TOKAMAK

[1,a]**Y. LIANG**, [2]S. ZHOU, [3]J. YANG, [1,2]J.K. HUA, [1]Y.T. YANG, [2]W. XIE, [2]N.C. WANG, [4]X.L. ZHANG, [1]A. KNIEPS, [1]S. XU, [1]E.H. WANG, [2]Z.P. CHEN, [2]B. RAO, [2]Z.F. CHENG, [2]Q.H. YANG, [2]W. YAN, [2]Z.Y. CHEN, [2]Y.H. DING, [5]Y. SUZUKI, [1]C. LINSMEIER, AND THE J-TEXT TEAM

[1] Forschungszentrum Jülich GmbH, Institute of Fusion Energy and Nuclear Waste Management – Plasma Physics, 52425 Jülich, Germany

[2] Huazhong University of Science and Technology, Wuhan 430074, China

[3] Institute of Metal Research Chinese Academy of Sciences, Shenyang, China

[4] Southwestern Institute of Physics, Chengdu 610041, People's Republic of China

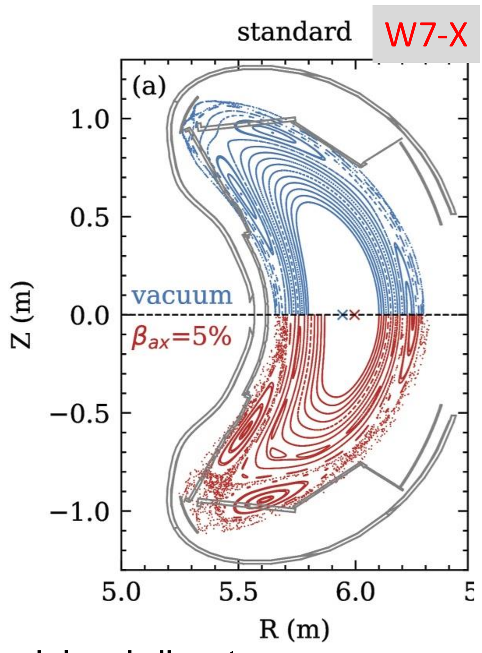
[5] Hiroshima University, Higashi-Hiroshima, Japan

[a]E-mail: y.liang@fz-juelich.de

Introduction

The development of advanced magnetic divertor configurations to solve the core-edge integration, the coupling of heat and particle exhaust and impurity control in high-power high-performance long-pulse plasma operation is one of the important topics in current fusion research, and is being carried out in more and more tokamak and stellarator devices.

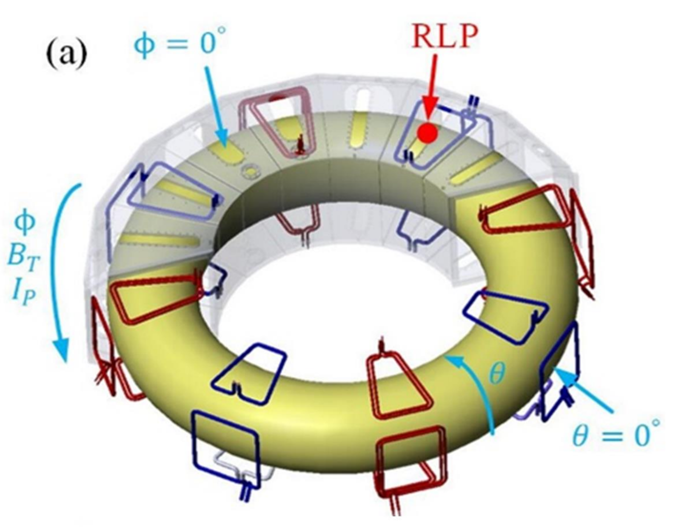
- The island divertor, one of multiple attractive advanced divertor concepts, has been successfully applied on the W7-AS stellarator, and further developed on the W7-X stellarator. In the island divertor configuration, the SOL is formed by a group of magnetic islands, which form closed flux tubes around the core plasma. These edge islands are then intersected and cut open by divertor target plates.
- Compared with the standard poloidal divertor configuration, the island divertor configuration has a weaker correlation with the plasma current and a longer connection length, which results in a wider distribution of heat loads and also makes it easier to enter stable detachment of divertor operation [1].

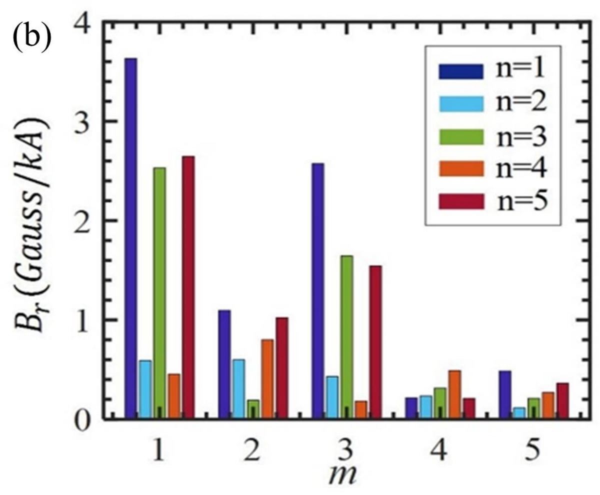


Therefore, it is of great interest to apply and explore the island divertor configuration in tokamak plasmas. Recently, a first attempt has been made to form an island divertor configuration in the J-TEXT tokamak [2, 3].

Experimental Set-up of Resonant Magnetic Perturbation (RMP) Coils on J-TEXT [4 - 7]

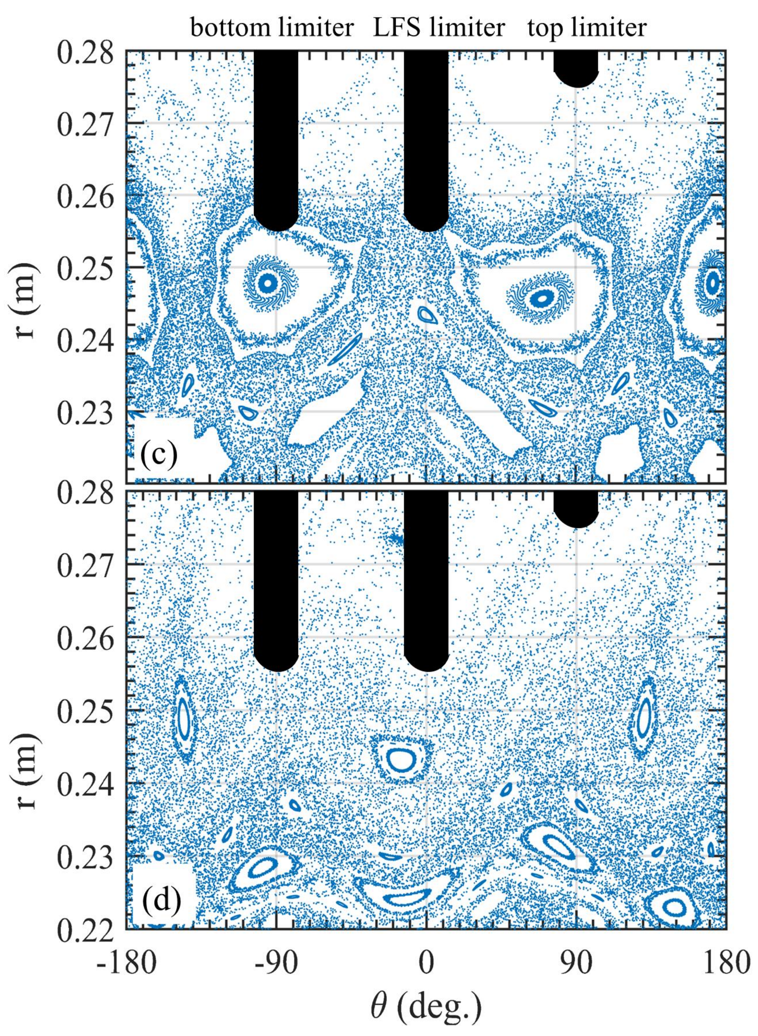
Layout of the RMP coils in J-TEXT, and the position of the reciprocating Langmuir probe





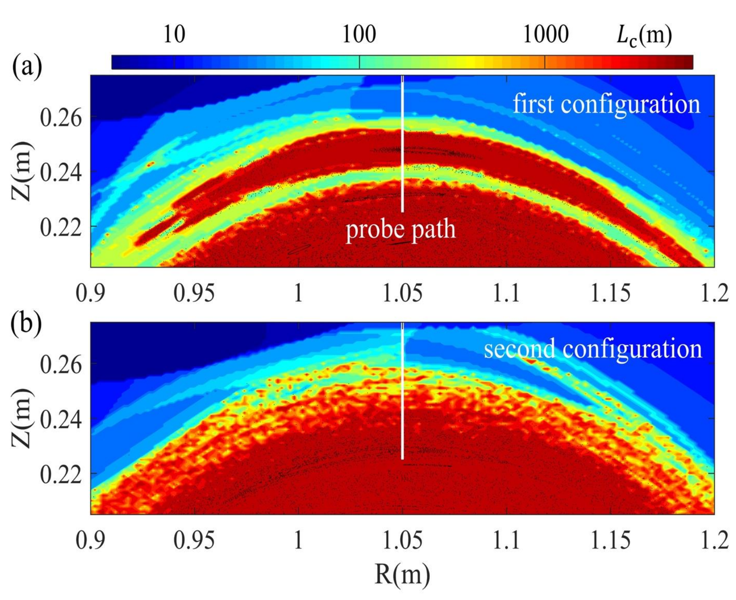
2D Fourier (m, n) spectrum of the radial magnetic field generated by RMP coils at the plasma edge

Poincaré plots of the plasma cross-section ϕ_{tol}= 337.5° for first and second RMP configurations, with three limiters at ϕ_{tol}= 337.5° indicated by black rectangles



Configuration	Polarity of RMP coils	Discharge	I_{RMP} (kA)	I_p (kA)	q_a
First	— + + + + — — —	1056 894	4	150	3.4
	+ — — — — 0 + +	1056 901		160	3.2
		1056 903	3	180	2.8
Second	+ — — — — + + +	1056 898	4	160	3.2
	— + + + + 0 — —	1056 905	3	150–180	3.4–2.8

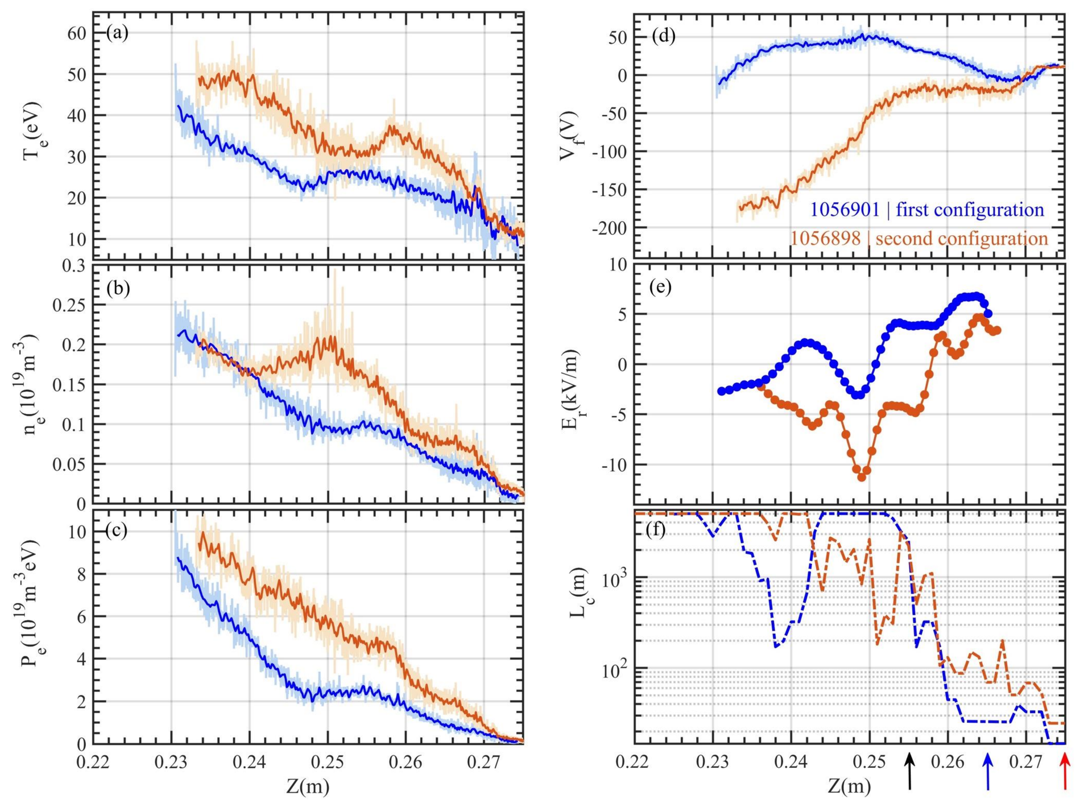
RMP coil setup and plasma parameters implemented in the experiment.

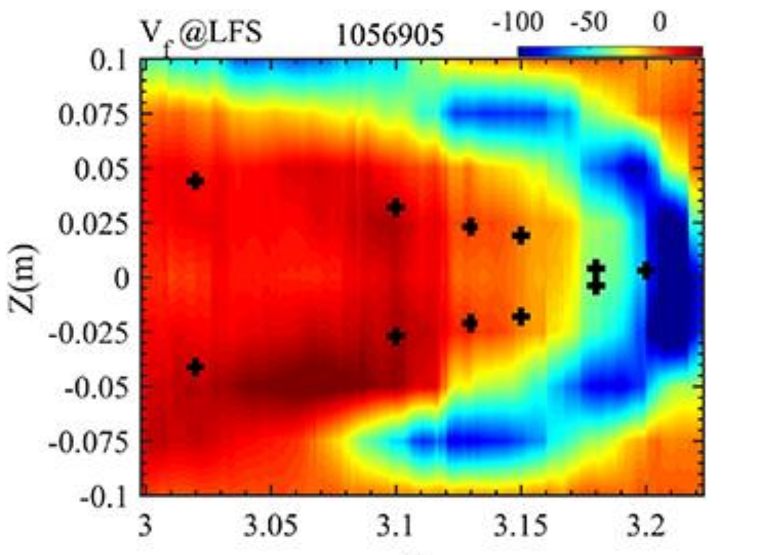


The connection length $L_c(R,Z)$ for two different RMP configurations

Formation of island divertor configuration [4]

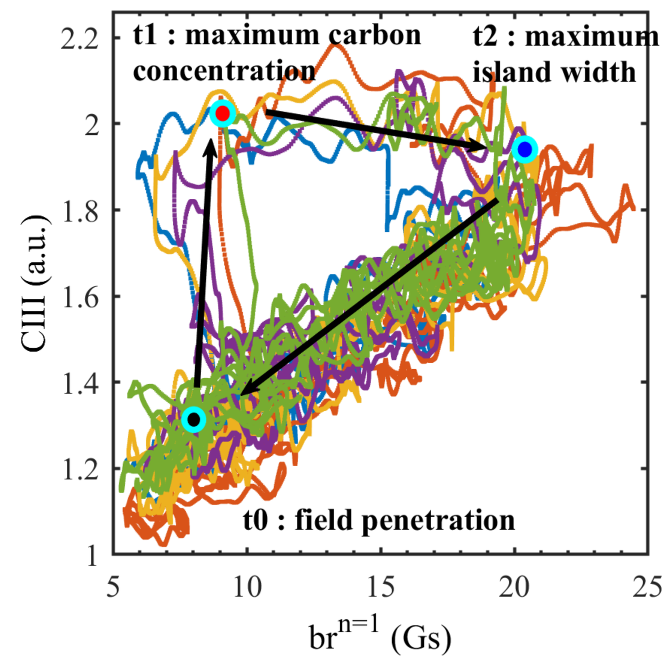
Radial profiles in the experiments of RMP configuration-dependence





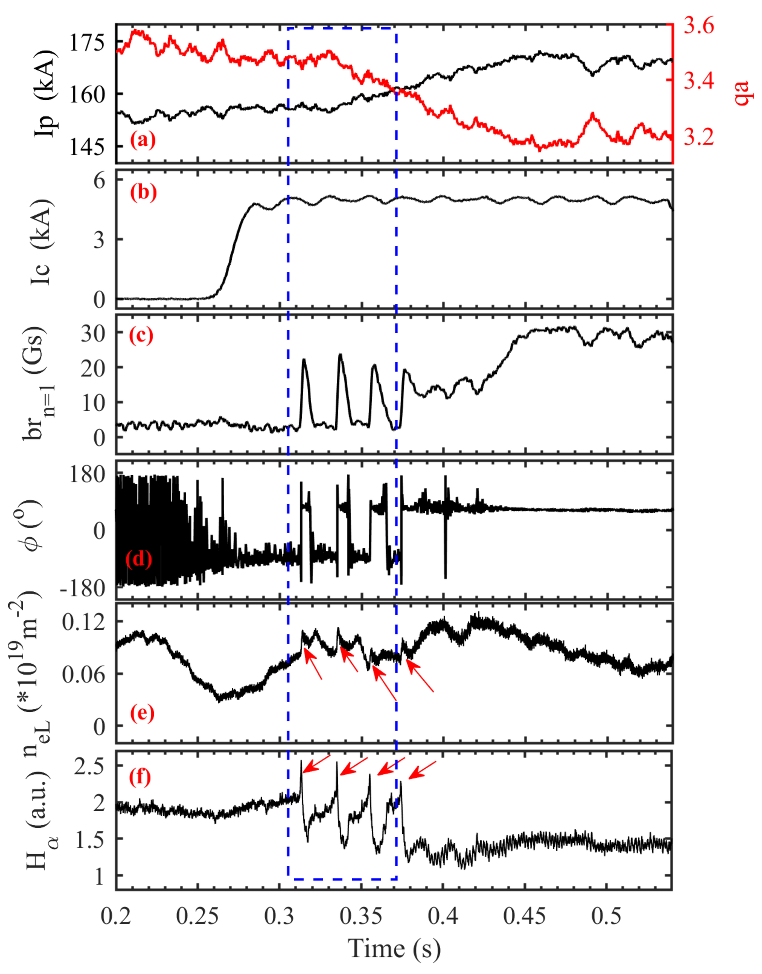
Dependence of LFS floating potential distribution on edge safety factor q_a.

Stability of edge island [8]

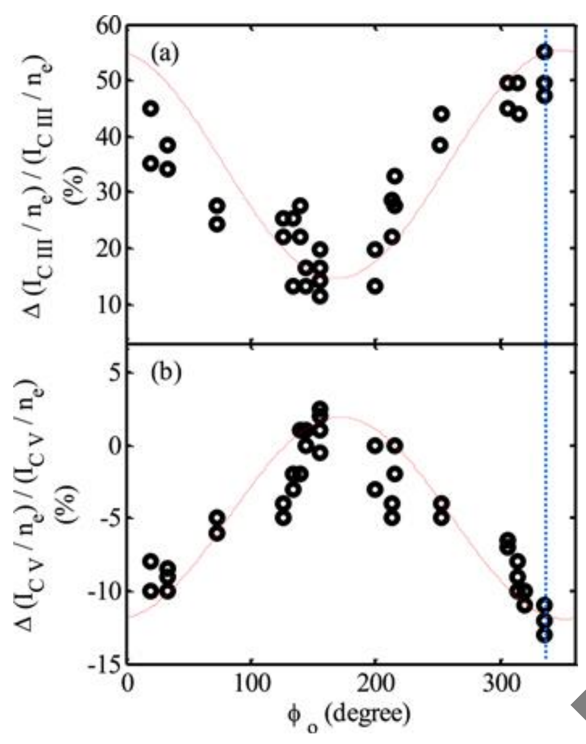


The relation between CIII and b_r during five collapses

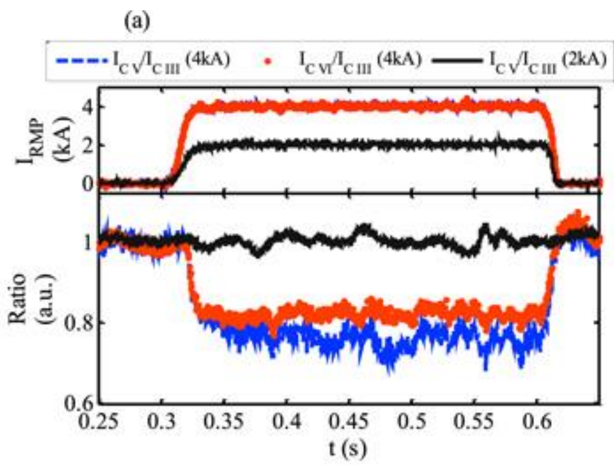
Overview of the discharge #1077700



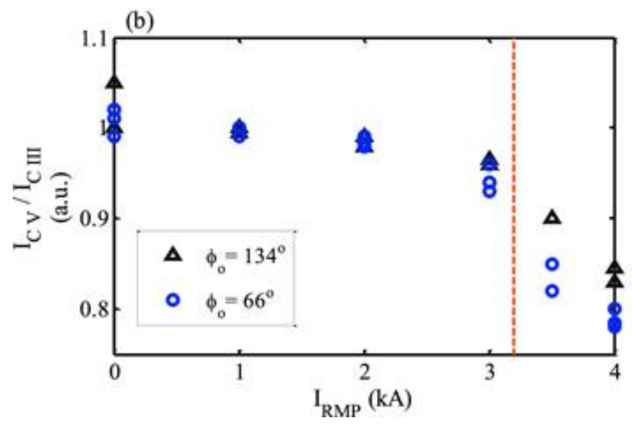
Impurity screening effects [9]



Time evolution of the RMP coil current and the ratio of $I_{C\,V}/I_{C\,III}$ (blue dotted line) and $I_{C\,V}/I_{C\,III}$ (red dots) with I_{RMP} = 4 kA, $I_{C\,V}/I_{C\,III}$ (black line) with I_{RMP} = 2 kA.



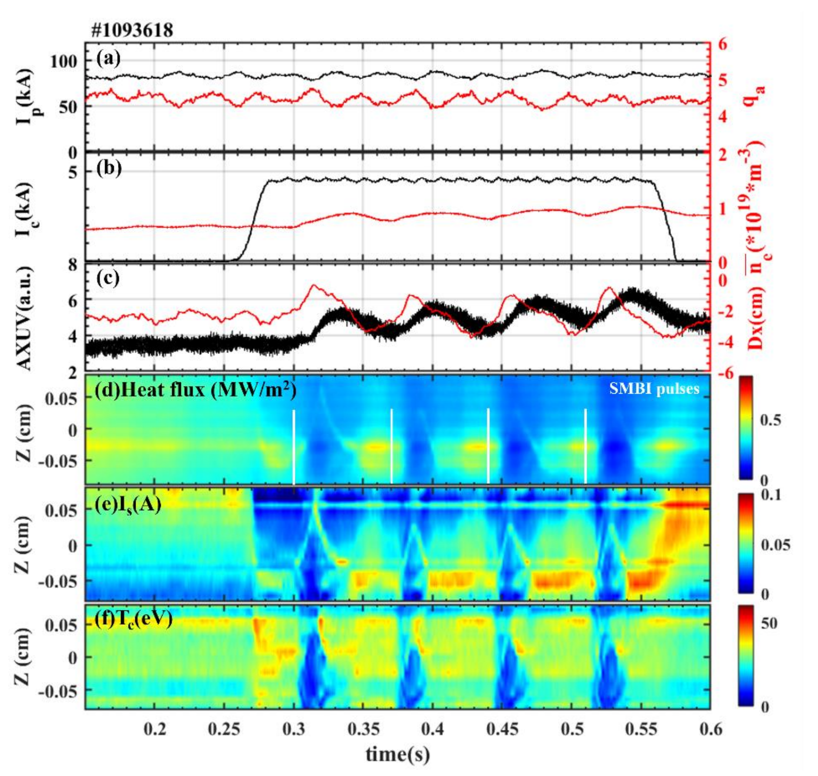
Statistical relationship between ratio of $I_{C\,V}/I_{C\,III}$ and RMP current; red dashed line indicates the threshold of 3/1 penetration.



The RMP phase (φ_o) dependence of normalized changes of the $I_{C\,V}/n_e$ and $I_{C\,III}/n_e$ with 3/1 locked magnetic island. The blue dotted line indicates the LFS limiter position

3D divertor heat loads [10-11]

Time evolution of (a) I_P and q_a, (b) the I_c and central line-averaged density $\overline{n_e}$, (c) the total radiation loss and the horizontal displacement of plasma, (d) the HFS target heat flux distribution and the SMBI injection time, (e) the contour of the ion saturation current I_s, (f) the contour of the electron temperature T_e.



Summary

- A first attempt has been made to form an island divertor configuration using a set of RMP coils in the J-TEXT tokamak.
- A new type of edge island instability, the so-called self-sustained divertor oscillation, was observed in J-TEXT during divertor experiments. The periodic collapses repeat several times until the edge islands are intersected by the divertor target.
- It is found that the m/n = 3/1 islands have an impurity screening effect, which becomes obvious while the edge magnetic island is generated via RMP field penetration.
- Power detachment can be achieved when the radiation front approaches the last closed flux surface after each SMBI pulse.

References

1. M. Jakubowski et al 2021 Nucl. Fusion 61 106003
2. Y. Liang et al 2022 Plasma Sci. Technol. 24 124021
3. S. Zhou, et al 2025 Nucl. Fusion 65 016020
4. J. Yang, et al 2024 Nucl. Fusion 64 056030
5. Y. Liang, et al 2019 Nucl. Fusion 59 112016
6. B. Rao, et al 2014 Fusion Eng. Des. 89 378
7. Y. Suzuki, 2017 Plasma Phys. Control. Fusion 59 054008
8. J.K. Hua, Y. Liang et al., 2025 submitted to Nuclear Fusion
9. X.L. Zhang et al 2021 Plasma Sci. Technol. 23 125101
10. S. Zhou et al 2022 Nucl. Fusion 62 106002
11. Y.T. Yang et al 2024 Plasma Sci. Technol. 26 125102

EUROfusion

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.