IMPACT OF THE TEMPERATURE RATIO ON TURBULENCE AND IMPURITY TRANSPORT IN THE EAST PLASMA CORE

[1]G.S. LI, [1]T. ZHANG, [2]Z. XU, [1]K.N. GENG, [1]X.X. ZHANG, [1]K.D. LI, [1]S.X. WANG, [1]F. WEN, [1]X.J. Liu, [1]X.H. WU, [1]Y.J. LIU, [1]T. LAN, [1]H.Q. LIU, [1]G.Q. LI, [1]X. GAO and the EAST team

[1]Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, People's Republic of China
[2]School of Electrical and Optoelectronic Engineering, West Anhui University

Email: gsli@ipp.ac.cn

Achieving fusion reactions requires heating the fuel to extremely high temperatures and effectively confining it. Turbulent transport plays a crucial role in affecting plasma confinement [1]. Therefore, studying the turbulent transport mechanisms under fusion reactor conditions (with a temperature ratio of Te/Ti ~1) is of significant importance. The injection of light argon impurities can suppress the micro-instabilities that dominate plasma heat transport, thereby enhancing confinement. On the other hand, these micro-instabilities can also drive impurity transport. Thus, argon impurities can serve as tracer particles to investigate the interplay between turbulent transport and impurity behavior in the plasma core. An experiment was specifically conducted on the EAST device to study the turbulent impurity transport processes in the plasma core by adjusting the temperature ratio to regulate the turbulence level.

The experimental setup is illustrated in Figure 1 below. The three discharges share similar waveforms, with 2MW NBI serving as the background heating, and the plasma density is feedback-controlled at an identical level to mitigate the effects of rotation and density peaking. Here, EC is adjusted to different power levels to modulate the central electron-ion temperature ratio, thus producing varying degrees of turbulence in the plasma core. Equal amounts of argon impurities are injected through SMBI on different EC heating power platforms. Following the injection of argon impurities, both the plasma toroidal rotation velocity and ion temperature rise, while the ion-scale density fluctuations measured by the microwave reflectometer at rho=0.4-0.5 also gradually increase. Figures 2 (a1)-(a2) present a comparison of the electron density, electron temperature, and ion temperature profiles before and after the argon impurity seeding. A significant increase in the ion temperature gradient is observed, which is likely to trigger more ITG turbulence. This could be a key factor behind the rise in ion-scale density fluctuations as measured by the microwave reflectometer. The elevation in Ti can be attributed to the stabilization of TEM due to the impurity effect, which is confirmed by the TGYRO simulation (see Figure 2 (b1)-(b4)). A comparison of these three discharges is presented by aligning the timing of the argon impurity injection to t=0 in Figure 3(a1)-(a3). Notably, discharge #139946 shows the highest core electron-ion temperature ratio and the lowest turbulence level measured by the microwave reflectometer. Additionally, it has the largest change in effective Zeff before and after the argon impurity seeding, indicating the highest impurity concentration in the plasma core. Concurrently, it also experiences the most substantial increase in ion temperature. In contrast, the other two discharges (#139949 and #139955) exhibit less pronounced changes in these aspects. Furthermore, following the argon impurity seeding, there is a rise in ion temperature accompanied by a slight decrease in electron temperature and a gradual peaking of the density profiles, as depicted in Figure 3(b1)-(b4).

This result can be summarized as follows: the injection of argon impurities suppresses TEM turbulence and thus helps to increase the ion temperature. However, the level of ITG turbulence affects the confinement and content of argon impurities through impurity turbulent transport, thereby influencing the degree of ion temperature increase. This provides a clear picture of the interaction between turbulence behaviors and impurity transport in the plasma core. By the way, this is consistent with the experimental observation in Wendelstein 7-X that impurity confinement can be elucidated by turbulent transport [2]. We believe that this work is beneficial for understanding turbulence and impurity transport in the plasma core of tokamak devices, as well as for exploring ways to control and reduce anomalous transport.

ACKNOWLEDGEMENTS

This work has been supported by the National Key R&D Program of China (No. 2022YFE03050003) and the National Nature Science Foundation of China (No. 12275315). This work is partly supported by the Science Foundation of Institute of Plasma Physics, Chinese Academy of Sciences (No. DSJJ-2024-08).

REFERENCES

[1] M. Yoshida et al 2025 Nucl. Fusion 65 033001
[2] Th. Wegner *et al* 2020 Nucl. Fusion 60 124004.

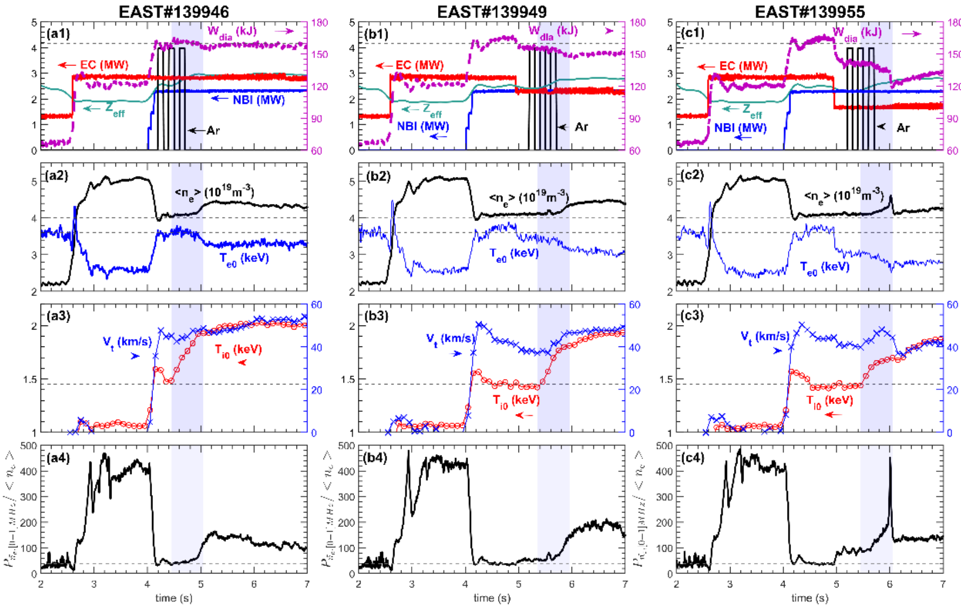

Fig 1. Experimental setup. Three discharges have the similar waveform, but different EC power.

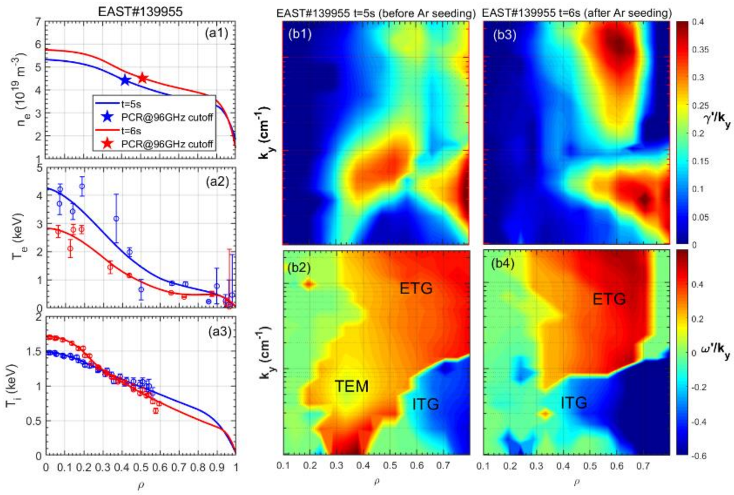

Fig 2. (a1)-(a2) The ne, Te and Ti profiles before and after Ar seeding. (b1)-(b4) Results of TGYRO simulation shows that the increased Ti is due to the stabilization of TEM.

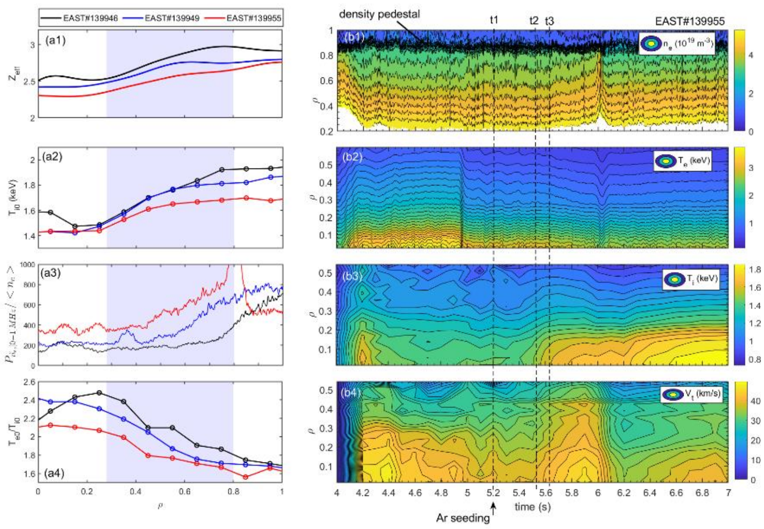

Fig 3. (a1)-(a4) A comparison of three shots reveals that varying electron-ion temperature ratios lead to different levels of density fluctuations, resulting in disparate changes in Zeff and enhanced ion temperature. (b1)-(b4)The evolution of ion temperature, electron temperature, electron density, and rotation velocity before and after argon impurities seeding.