5. Japan-China Collaboration for Fusion Research (Post-CUP Collaboration)

I. Post-CUP collaboration

The post-CUP collaboration is motivated by collaboration with Southwestern Institute of Physics (SWIP), other institutes and universities in China for fusion research. The SWIP is now operating HL-2A tokamak and starts to construct HL-2M tokamak, of which the operation from 2017 is expected, for further fusion studies. Collaboration with Institute of Plasma Physics Chinese Academy of Science (ASIPP), University of Science and Technology of China (USTC) and Huazhong University of Science and Technology (HUST) are basically included in the A3 Foresight Program financed by the Japan Society for the Promotion of Science (JSPS), of which the institutions are operating EAST tokamak, J-TEXT tokamak and KTX reversed Field pinch devices. The Post-CUP collaboration is basically carried out for both the studies on plasma physics and fusion engineering, while the A3 program is carried out only for plasma physics required for steady state sustainment of fusion plasmas.

II. Seminars between Japan and China

The 5th Japan-China joint seminar on atomic & molecular processes in plasmas was held in Northwest Normal University at Lanzhou, China during 28th July - 1st August [1]. Totally 25 scientists (12 Japanese and 13 Chinese) joined the seminar with many Chinese students. Fruitful discussions were made on spectroscopy and atomic structure of tungsten in addition to experimental and theoretical presentations including results from Shanghai-, Tokyo- and NIFS-EBITs, HL-2A, EAST and LHD.

The 12th Japan-China Symposium on materials for advanced energy systems and fission & fusion engineering was held in Shizuoka, Japan during 17th-20th September [2]. Totally 72 scientists (43 Japanese, 25 Chinese, 4 others) and 28 students (24 Japanese, 4 Chinese) joined the symposium. Productive presentations and fruituful discussions were made in the fields of reactor system & design, blanket & first wall technology, fission materials & fuels, fusion materials, radiation effects, data base & modeling and ITER related issues.

III. Activities of collaboration in FY 2014

In 2014 FY 5 scientists visited at SWIP. Some of the results are described in the following.

Experiments for investigating an effect of turbulence on plasma confinement were done in HL-2A. For the purpose the lower-Hybrid (LH) wave heating was attempted to produce an H-mode plasma. However, impurity influx originated in the LH antenna quickly increased during the LH heating. The discharge was terminated by excitation of MHD instabilities. It seems that the increased impurity radiation changes the current profile and triggers the classical tearing mode (locked mode). The mode rotation is reduced and then a current disruption occurs after the rotation stop. This phenomenon has been widely observed in various tokamaks and interpreted with "cold front" created by the inward impurity propagation. When the cold front approaches a resonant surface (q = 2), a steep gradient is formed in the plasma current and the pressure, by which the instability is grown up. This phenomenon is frequently used for an active disruption study and disruption mitigation based on a decay time control of the net plasma current. In order to prepare magnetic diagnostics for HL-2M, a diamagnetic flux loop, magnetic probe array, one-turn loops, Rogowski coils and data storage (ADC) were also discussed with material selection and calibration method for the diagnostic systems.

Impurity transport in the scrape-off layer (SOL) has been studied in ohmically heated discharges of the HL-2A tokamak based on space-resolved vacuum ultraviolet spectroscopy [3,4]. The radial profile of carbon emissions of CIII (977 Å: $2s^2\ ^1S_0$-$2s2p\ ^1P_1$) and CIV (1548 Å: $2s\ ^2S$-$2p\ ^2P$) as well as the ratio of CIV to CIII is measured to investigate the edge impurity transport with relation to impurity source locations and sputtering characteristics. The experimental result shows that the impurity profile in the SOL has been clearly changed against different source locations. The profile of CIII and CIV becomes flat for divertor source and peaked at the plasma edge for dome source. It becomes further peaked at the edge for limiter source. The density turning point seen in the density dependence of CIII, CIV and CIV/CIII values, i.e. 2.6×10^{19} m^{-3}, gives a critical density in the edge impurity transport. When the density is less than the critical value, the edge impurity screening is week.

A new scintillator-based lost fast-ion probe (SLIP) has been developed and operated in HL-2A to measure the NB ion loss [5]. The probe is capable of traveling across an equatorial plane port and sweeping the aperture angle rotationally with respect to the axis of the probe shaft by two step motors to optimize the radial position and the collimator angle. The energy and pitch angle of lost fast ions can be simultaneously measured if two-dimensional image of scintillation light intensity due to the impact of lost fast ions is detected. The fast-ion loss using the probe has been measured during HL-2A NBI discharges. A clear experimental evidence of enhanced losses of the beam ion was obtained during disruptions with the SLIP system.

[1] Proceedings are published in NIFS-PROC (2015).
[2] J. Plasma and Fusion Research SERIES **11** (2015).
[3] Cui Z.Y., Morita S., et al., to be published in Nucl. Fus.
[4] Cui Z.Y., Morita S., et al., RSI **85** (2014) 11E426.
[5] Zhang Y.P., Isobe M., et al., RSI **85** (2014) 053502.

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