§3. Collaborative Research of Magnetic Reconnection among Laboratory, Observation and Simulation

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In fiscal year 2012, we promoted a new style of collaborative plasma research of magnetic reconnection among laboratory experiment, solar and magnetosphere observation and theory/ simulation by starting several joint research groups composed of Hinode solar satellite team, laboratory experiments at Univ. Tokyo, NIFS simulation team and NIFS diagnostic team, JAERI simulation team, AIST NBI team. These activities finally lead us to the first joint paper on light bridge by collaborative works of TS laboratory experiment and Hinode solar observations. We made about 10 invited talks and published about 20 journal papers related with this collaboration program.

As shown in Fig.1, our Hinode-TS joint research team simulated the light-bridge phenomenon in solar chromosphere using a spheromak plasma with center solenoid flux in TS-4 ST devices. Its key issues are that a current sheet is formed between the spheromak and the magnetic flux by the center solenoid, causing that reconnection jet similar to that observed in the periphery of the light bridge. Figure 1(left) clearly shows the formation of current sheet between the spheromak and the solenoid flux. Our Mach probe array measured directly the reconnection jet from the current sheet just like the plasma jet from the light bridge. The jet turned out to be the reconnection outflow whose the speed is as high as Mach number 0.3-0.4, as shown in Fig. 1 (right). This outflow jet causes the ion heating in the downstream area over 20 eV. This laboratory simulation of light bridge was successful, leading us to our publication of our joint Astrophysical journal paper and U-Tokyo and ISAS announce at the press conference.

NIFS-TS team investigated the cause and mechanism for reconnection heating by using both of particle (PIC) simulations code developed by NIFS and TS merging/ reconnection experiment in Univ. Tokyo. In MHD regime, the reconnection outflow heats ions in the downstream but in kinetic regime, the magnetized electrons forms the negative potential well in the downstream, accelerating unmagnetized ions. This heating model/ mechanism initially proposed by Horiuchi[2] was compared under the common condition with guide (toroidal) magnetic field between the PIC simulation and TS experiments and found the common tilted potential well structure.

TS-NIFS-AIST-MAST joint team demonstrated the significant reconnection heating of ions and electrons 0.2keV in TS-3 experiment and 1.2keV in the MAST experiment, indicating that the reconnection heating is useful for high-power heating/ statup of tokamak plasmas. The reconnection heating energy scales with square of the reconnecting magnetic field in both experiment and also have weak dependence on guide magnetic field. Those results were presented as the plenary talk of EPS 2012 and were published as an invited paper of Plasma Phys. Cont. Fusion 2012[3]

[1] N. Nishizuka, Y. Ono et al, Astrophys. J., 756, 152, (2012).
[2] R. Horiuchi et al., Phys. Plasmas 4, 277 (1997)
[3] Y Ono et al., Plasma Phys. Cont. Fus. 54, 124039, (2012).

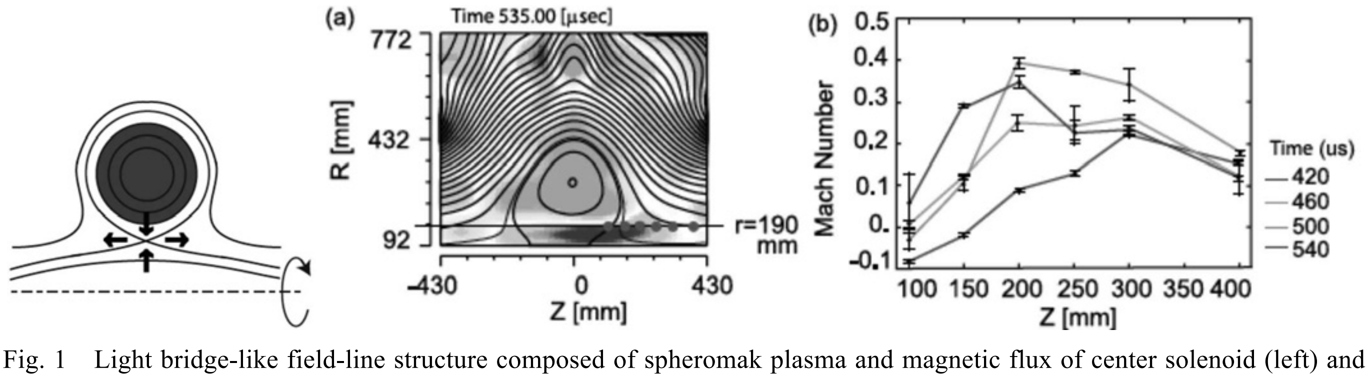

Fig. 1 Light bridge-like field-line structure composed of spheromak plasma and magnetic flux of center solenoid (left) and its poloidal flux contour with toroidal current density (middle) and its axial profile of axial plasma flow measured by Mach probe (right).