4. JSPS-CAS Core-University Program on Plasma and Nuclear Fusion

A bilateral international collaboration program *"JSPS-CAS Core-University Program (CUP) on Plasma and Nuclear Fusion"* was started from FY 2001 as a ten-year collaboration program. This program is supported by the Japan Society for the Promotion of Science (JSPS) on the Japanese side and by the Chinese Academy of Science (CAS) on the Chinese side. National Institute for Fusion Science (NIFS) and Institute of Plasma Physics, Chinese Academy of Science (ASIPP) serve as the core institutes for this program in each country and assist the collaborations between all participating institutes and universities in Japan and China. The CUP consists of three major research categories, that is, I: core plasmas for advanced fusion reactors, II: basic researches of fusion reactor technology, and III: theories and computer simulations of core plasma behavior. Each category has several research topics, as shown in Table I.

General review of collaboration in FY 2008

In the topics I-1A and I-1B, collaborative researches were carried out in three major tokamaks in China: EAST (ASIPP, Hefei), HL-2A (SWIP, Chengdu) and HT-7 (ASIPP). In Japan, collaboration experiments were carried out mainly in LHD (NIFS) and JT-60U (JAEA). These researches were focused on plasma transport and MHD stability, aiming at obtaining and understanding high performance plasmas such as H-mode, ITB plasma, plasma with full non-inductively driven current and so on. An important event in this fiscal year is the shut down of JT-60U tokamak started in operation since 1985. The JT-60U is up-graded in after 7 to 8 years, to be a full superconducting tokamak JT-60SA in the framework of "the Broader Approach" between EU and Japan. In HL-2A, heating experiments of deuterium plasma by neutral beam injection have been started. D-D neutrons were detected during an NBI pulse. MHD instabilities by supra-thermal electrons, "electron fishbone instabilities" were investigated in detail, using high power ECH. Large progress was made on experimental studies on particle and energy transport, geodesic acoustic mode (GAM) and zonal flow, divertor plasma and so on. Stabilization of m=2/n=1 neoclassical tearing driven modes was attempted with localized ECCD in JT-60U as a collaboration experiment. In JT-60U, pedestal, ELMs, resistive wall mode, spontaneous plasma rotation and other important issues were investigated toward ITER and JT-60SA. Very high density plasma and high ion temperature plasma in LHD were studied as a collaborative research. In parallel, collaborations in development of high power plasma heating system, heating scenarios and advanced plasma diagnostics were intensively carried out. High power CW oscillator of 1.5MW for ICRF heating of the EAST plasma is under construction for plasma heating of an EAST plasma. These collaboration results in I-1A and I-1B for recent several years were discussed and summarized in the JSPS-CAS CUP seminar on "Production and control of high performance plasmas with advanced heating and diagnostic systems" held at Lijiang, China.

In the topic I-2A, material samples were exposed in various types of plasmas of HT-7 and EAST tokamaks and were analyzed both in China and Japan. Absorption and desorption of hydrogen, deuterium and helium gases in torus wall were intensively studied in LHD, EAST and HT-7, as a preparatory experiment of tritium retention in a fusion reactor such as ITER. Collaboration results in I-3A for recent several years were discussed and summarized in the JSPS-CAS CUP seminar on "Plasma wall interaction/ plasma facing components and Fusion Technology" held at Huangshan, China.

In the topic I-3A, various atomic and molecular processes in high and low temperature plasmas were studied as collaborative researches for basic understanding of atomic/molecular physics and applications to fusion plasmas.

Collaboration researches in I-5A and I-5B were continued in the fields of ultra-high density plasmas produced by intense laser and application of these kinds of plasma to other purposes. The JSPS-CAS CUP seminar on "Laser-Plasma interaction and Laser Target Material" was held in Osaka, Japan and fine-fabrication method of a target capsule and related various technologies were discussed. Experts of both countries investigated a possibility of terra-Hertz wave generation by means of plasma waves resonantly excited in non-uniform plasma. Interaction between ultra-short pulse high-power laser and plasma was studied by using numerical simulation. Relativistic plasmas driven by thus high power laser were also discussed from point of view of fast ignition, laser space physics and so on.

In collaborations in II-A, II-D, II-E and II-F, fabrication technologies of materials for plasma facing components, control and operation technologies of super-conducting coils and refrigerator with high accuracy and reliability, tritium behaviors in a rector blanket, integration of various technologies on neutron, heat, mechanical structure and materials were investigated toward more realistic design of an advanced fusion reactor.

In III-A to III-D, geodesic acoustic mode (GAM) in a tokamak plasma was analyzed theoretically and the scaling laws on plasma size and elongation were derived. Turbulent transport in multi-scale plasmas was investigated theoretically and with numerical simulations. Non-local electron transport observed in HL-2A was theoretically analyzed from a point of view of stability of a plasma having large fraction of energetic electrons. Nonlinear excitation of GAM in turbulent tokamak plasmas was investigated using gyro-fluid simulation. Multi-layered and multi-scale

simulation scheme was discussed to study complexity of a plasma. Numerical simulation code based on simplified Core-SOL-Divertor model was developed and applied to various types of EAST and HL-2A tokamak plasmas. This provided an important operation scenarios in these tokamaks.

The collaboration programs implemented in FY2008 are summarized in Table 1 for each research category.

Table 1 STATISTICAL REVIEW OF CUP collaborations in FY2008

Research Topics		J→C person (person-day)	C→J person (person-day)	**Total** person (person-day)
I-1A	Development of Advanced Plasma Heating for High-Performance Plasma Confinement	4 (25)	6 (77)	10 (102)
I-1B	Development of Diagnostic and Control Methods for High-Performance Plasma Confinement	10 (82)	12 (168)	22 (250)
I-2A	Study on Plasma-Surface Interactions and Plasma Facing Materials	4 (26)	6 (110)	10 (136)
I-3A	Atomic and molecular processes in plasma	4 (10)	6 (94)	10 (104)
I-4C	Development of High Pressure Plasmas for Environmental Application and Materials Processing	2 (14)	2 (24)	4 (38)
I-5A	Research of Ultrahigh Density Plasma (Inertial Confinement Fusion)	4 (20)	3 (39)	7 (59)
I-5B	Theory and simulation on Inertial Fusion Plasmas	3 (10)	6 (54)	9 (64)
II-A	Study on Reduced Activation Materials for Fusion	3 (13)	4 (38)	7 (51)
II-D	Development of superconducting key technology for advanced fusion reactor	4 (26)	4 (40)	8 (66)
II-E	Study of tritium behavior in solid and liquid breeder materials	2 (12)	3 (52)	5 (64)
II-F	Advanced reactor design and technological integration	3 (17)	3 (67)	6 (84)
III-A	Study on Theoretical Analysis of MHD and Micro-instabilities in Plasmas	2 (12)	2 (28)	4 (40)
III-B	Study on Transport Theory: Code Development of Numerical Analysis and Confinement Improved Mode in Torus Plasmas	1 (4)	0 (0)	1 (4)
III-C	Physics of self-organization in Complex plasmas	1 (4)	2 (16)	3 (20)
III-D	Modeling of edge and diverter plasma and control of impurities and recycling particles	2 (18)	2 (21)	4 (39)
	Scientist Exchange	2 (8)	6(24)	8 (32)
Grand Total		51 (301)	67 (852)	118 (1153)

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