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 behaviors. Each category has several research topics, as shown in Table I.

General review of collaboration in FY 2009

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), H-J (Kyoto Univ.) and QUEST (Kyushu Univ.), since the JT-60U experiments were shut down in the last fiscal year. These researches were focused on plasma transport and MHD stability, aiming at obtaining and understanding high performance plasmas such as H-mode, ITB plasma, plasmas with full non-inductively driven current, edge turbulence and so on. The JT-60U is being up-graded as a full superconducting tokamak JT-60SA in the framework of "the Broader Approach" between Japan and EU. In HL-2A, heating experiments of deuterium plasma by neutral beam injection and electron cyclotron waves were conducted. Characteristics of H-modes achieved in the heating experiments were studied. MHD instabilities excited by supra-thermal electrons, "electron fishbone instabilities" were investigated in detail, using high power ECH. Alfven eigenmodes (AEs) excited by energetic ions and beta induced AE (BAE) generated through magnetic island coupling were investigated. Large progress has been made in 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 modes was attempted with localized ECCD. Very high density plasmas and high ion temperature plasmas in LHD were studied as a collaborative research. In parallel, development of high power plasma heating systems, heating scenarios and advanced plasma diagnostics has progressed as collaborative researches. High power oscillator of ~1MW for ICRF heating of the EAST plasma was first applied to the EAST experiments.

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. Experiments on absorption and desorption of hydrogen, deuterium and helium gases in torus wall were continued in LHD, EAST and HT-7, as a preparatory experiment of tritium retention in a fusion reactor such as ITER.

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 results in I-3A for recent several years were summarized in the JSPS-CAS CUP seminar on "Atomic and Molecular Processes in Plasma" held at Xi'an.

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. 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, global instabilities and geodesic acoustic mode (GAM) in a tokamak plasma were analyzed theoretically. Theoretical approaches to study interaction between MHD instabilities and ambient micro turbulence were discussed. Turbulent transport in multi-scale plasmas was investigated theoretically. Numerical simulations were also attempted. Non-local electron transport observed in HL-2A was theoretically analyzed from a point of view of the stability of 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 plasma. Numerical simulation based on simplified Core-SOL-Divertor model was applied to EAST and HL-2A tokamak plasmas. Theoretical study on dust formation in fusion plasma was started as a key issue to de clarified near future.

The collaboration programs implemented in FY2009 are summarized in Table 1 for each research category.

In addition, the coordinators of CUP in both sides

reported the collaboration structure and size, and key results of 8 years collaboration, at the "Commemorative Event for 30-Year JSPS-CAS Partnership", which was organized by JSPS at Tokyo on Sep. 15, 2009.

Table 1 Statistical Summary of CUP collaborations in FY2009

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	7(52)	4(56)	11(108)
I-1B	Development of Diagnostic and Control Methods for High-Performance Plasma Confinement	12 (100)	17(201)	29(301)
I-2A	Study on Plasma-Surface Interactions and Plasma Facing Materials	6(42)	8(120)	14(162)
I-3A	Atomic and molecular processes in plasma	3(18)	6(74)	9(92)
I-4C	Development of High Pressure Plasmas for Environmental Application and Materials Processing	3(25)	3(36)	6(61)
I-5A	Research of Ultrahigh Density Plasma (Inertial Confinement Fusion)	4(19)	6(49)	10(68)
I-5B	Theory and simulation on Inertial Fusion Plasmas	5(20)	7(49)	12(69)
II-A	Study on Reduced Activation Materials for Fusion	3(19)	3(39)	6(58)
II-D	Development of superconducting key technology for advanced fusion reactor	5(33)	6(48)	11(81)
II-E	Study of tritium behavior in solid and liquid breeder materials	3(16)	4(70)	7(86)
II-F	Advanced reactor design and technological integration	3(15)	3(79)	6(94)
III-A	Study on Theoretical Analysis of MHD and Micro-instabilities in Plasmas	2(8)	2(28)	4(36)
III-B	Study on Transport Theory: Code Development of Numerical Analysis and Confinement Improved Mode in Torus Plasmas	2(12)	2(28)	4(40)
III-C	Physics of self-organization in Complex plasmas	2(14)	3(36)	5(50)
III-D	Modeling of edge and diverter plasma and control of impurities and recycling particles	1(12)	2(17)	3(29)
	Scientist Exchange	2(8)	6(30)	8(38)
Grand Total		63(413)	82(960)	145(1373)

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