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. This was implemented as the second year of the latter five-year program approved by JSPS in 2005.

The CUP consists of three major research categories, that is, I: core plasma, 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 2007

In the topics I-1A and I-1B, collaborative researches were carried out in three major tokamaks in China: EAST (ASIPP, Hefei), HL-2A (SWIPs, Chengdu) and HT-7 (ASIPP). In Japan, collaboration experiments were carried out mainly in JT-60U (JAEA) and LHD (NIFS). 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. In HL-2A, particle transport was studied with a microwave reflectometer in a gas-puff modulation experiment. Poloidal plasma rotation was also derived from Doppler shift of reflected microwaves. Stabilization of m=2/n=1 neoclassical tearing modes was attempted with localized ECCD in JT-60U as a collaboration experiment. In JT-60U, ELM and energetic ion confinement were also investigated. 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 for ICRF heating of the EAST plasma is under construction as a technological collaboration, of which specification is 1.5MW output and the frequency is tunable in the range of 25 MHz to 70 MHz. As an other collaboration, a groove mirror for polarization control of 68 GHz microwaves was designed and made for efficient ECH and ECCD in HL-2A. Real time measurement of antenna impedance for ICRF heating in LHD was tried in order to perform real time impedance control during long pulse ICRF heating for ESAT in future.

In the topic I-2A, material samples exposed to helium-oxygen plasmas produced by ICRF heating power in HT-7 were analyzed in Japan. It was confirmed that ICRH-produced oxygen plasma can effectively remove deposited layer on the samples and reduce deuterium absorbed in the sample.

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 Dunhuang. Various atomic and molecular processes in high and low temperature plasmas were discussed and most important issues to be addressed were extracted for future collaborations between China and Japan.

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 Target Material" was held in Huang Shan 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.

Collaborations in II-A, II-D, II-E and II-F were summarized and discussed the future direction in the JSPS-CAS CUP seminar on "Fusion Materials and System Design Integration" held at Guilin. Fabrication technologies of materials for plasma facing components, control and operation technologies of super-conducing 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 discussed in this seminar 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 law on plasma size was derived. A new type of current hall configuration in a tokamak plasma was theoretically discussed. 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 EAST and HL-2A tokamak plasmas.

The collaboration programs implemented in FY2007 are summarized in Table 1 for each research category.

Table 1 STATISTICAL REVIEW OF CUP collaborations in FY2007

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(33)	6 (64)	10(97)
I-1B	Development of Diagnostic and Control Methods for High-Performance Plasma Confinement	9(62)	10 (160)	19 (222)
I-2A	Study on Plasma-Surface Interactions and Plasma Facing Materials	5(33)	5 (79)	10 (112)
I-3A	Atomic and molecular processes in plasma	3(17)	7 (96)	9 (113)
I-4C	Development of High Pressure Plasmas for Environmental Application and Materials Processing	2 (17)	2 (25)	4 (42)
I-5A	Research of Ultrahigh Density Plasma (Inertial Confinement Fusion)	3 (22)	1 (14)	4 (36)
I-5B	Theory and simulation on Inertial Fusion Plasmas	4 (21)	3(30)	7 (51)
II-A	Study on Reduced Activation Materials for Fusion	3 (21)	6 (63)	9 (84)
II-D	Development of superconducting key technology for advanced fusion reactor	3 (21)	4 (59)	7 (80)
II-E	Study of tritium behavior in solid and liquid breeder materials	2 (10)	1(40)	3 (50)
II-F	Advanced reactor design and technological integration	3 (18)	3 (51)	6 (69)
III-A	Study on Theoretical Analysis of MHD and Micro-instabilities in Plasmas	2 (18)	3 (47)	5 (65)
III-B	Study on Transport Theory: Code Development of Numerical Analysis and Confinement Improved Mode in Torus Plasmas	1 (10)	2(35)	3 (45)
III-C	Physics of self-organization in Complex plasmas	1 (4)	2(20)	3 (24)
III-D	Modeling of edge and diverter plasma and control of impurities and recycling particles	1 (8)	1 (8)	2 (16)
	Scientist Exchange	1 (5)	5(20)	6 (25)
Grand Total		47 (320)	61 (811)	108 (1131)

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