Historical Review of Internationalization in Fusion Research in Japan -INTOR Workshop -

核融合研究国際化の歴史経緯 −INTORワークショップ−

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A real international collaboration in fusion research for Japan started in the late 1970s via two independent routes. One is the United Nation's INTOR workshop, which was an international design activity for the next generation fusion device after the big tokamaks like TFTR, JET and JT-60 under the auspices of IAEA (International Atomic Energy Agency). Another is the US-Japan collaboration program on energy research, which was initiated by the Fukuda-Carter meeting in May 1977. Although the two international collaborations in fusion researches started independently, they were strongly influenced by international politics just after the "Oil Shock" several years before. In this report, start-up processes of the INTOR workshop are described in detail based on the NIFS Fusion Science Archives (NIFS FSA).

1. Introduction

Successful T-3 tokamak experiment at Kruchatov Institute in USSR in the late 1960s after struggling phase of nuclear fusion research over two decades, and the world energy crisis, so-called oil shock, triggered by the 4th Middle East War in the early 1970s, attracted people's attention to a new energy resource all over the world. Nuclear fusion energy was considered to be one of the most attractive energy resources. Immediately, construction or proposal of large tokamaks (TFTR in USA, JET in European Communities, JT-60 in Japan, T-15 in USSR) started. It was a big jump for fusion research from both machine size and budget points of view. In the same time, design study for the experimental reactor as a next step device had been promoted in each country. In Japan, for example, design activity for Fusion Experimental Reactor (FER) had been started at Japan Atomic Energy Research Institute (JAERI). However, fusion research project is approaching a limit of a budget for a single country. In addition, a roadmap to a commercial reactor was not clear. A common recognition looking for international collaboration was growing. Two international collaboration programs had started in such background. They were the INTOR Workshop under the International Atomic Energy Agency (IAEA) and the US-Japan Collaboration Program under bilateral agreement in the late 1970s. In this report, start-up processes of the INTOR workshop is mainly described.

2. Establishment of INTOR Workshop

D. Rose of Massachusetts Institute of Technology (MIT), USA proposed an international collaboration in the next phase fusion research in 1977. A meeting (so-called Rose meeting) was held at MIT in October of this year. An invitation letter to Japan was sent to the Director of JAERI. T. Hiraoka attended the meeting as a representative of the Director. Based on the discussion at the meeting, D. Rose sent a letter to the Director General of IAEA to promote an international collaboration. The IAEA DG sent a letter (dated on January 17th, 1978) to the member countries of International Fusion Research Council (IFRC) asking for comment to the Rose's proposal. USSR was most active and immediately proposed construction of a next generation tokamak device under the international framework. At the IFRC meeting in May 10th – 12th, 1978, a decision was made to held a "Sub-Committee Meeting on this international collaboration", which K. Husimi attended as a Japanese representative. The Advisory Committee on Nuclear Fusion under the Japan Atomic Energy Commission discussed on this issue and sent S. Mori of JAERI to the IFRC Sub-Committee Meeting in place of K. Husimi for the discussion, especially on the Soviet proposal. The meeting was held on June 26th – 28th at IAEA Headquarters in Vienna. The members were S. Mori (JAERI, Japan), R. S. Pease (Chairperson, Culham Laboratory, UK), E. E. Kintner (DOE, USA), E. Velikhov (Kurchatov Institute, USSR), D. Palumbo

(Commission of EC) and some IAEA staff members including H. Kakihana as DDG. It was recommended to set up a periodic workshop, in which key issue is to crystallize technical objectives and nature of the apparatus. The decision was made at the IFRC meeting on August 21th – 22th to establish the Zero Phase Workshop, which did not commit machine construction. The IAEA DG approved this decision in September. R. S. Pease, as a chairperson of IFRC, sent a telex to S. Mori to be a chairperson of the workshop. Finally S. Mori was pointed as a chairperson, and thus Japan became the chair country. It was an epoch-making event in this age that a Japanese took a leadership for the international big project, because Japan was looked down as a latecomer in fusion research before this age. This was the process of the establishment of INTOR workshop as a first real international collaboration in fusion research.

2. The workshop procedure

The first steering committee meeting was held on November 20th - 23th. The members were W. M. Stacy, Jr. (Georgia Institute of Technology, USA), B. B. Kadomtsev (Kuruchatov Institute, USSR), G. Grieger (Max-Planck-Institute for Plasma Physics, EC), and S. Mori (JAERI, Japan). The tokamak reactor to be examined was designated the United Nations International Tokamak Reactor (UNITOR). However, the name was changed later to INTOR. The guideline for the machine design was decided: (1) The machine should be the maximum reasonable step to a commercial reactor from the present large tokamaks. (2) All basic components as a commercial reactor should be equipped. (3) System and component tests as a commercial reactor should be carried out. A realistic machine to answer these requests could be a D-T tokamak reactor with $Q > 5$. All engineering tests (material, tritium handling, superconducting coils, etc.) should be available by carrying out long pulse operation and demonstration of electricity generation. The final report has to be presented a year later.

The first session of the INTOR Workshop started on February 5th – 16th, 1979. The members are listed in the table I.

The workshop was held four times in a year with two-week intensive work for each time. Much homework had been carried back to each home country, where many researchers contributed to solve the issues for the next workshop. A year later, a final report for the Zero Phase Workshop was published, suggesting a necessity to continue the international collaboration as a Definition Phase (later, it was called Phase One workshop).

Table I. Zero phase workshop members

Japan	USSR
S. Mori (Chair) T. Hiraoka K. Sako T. Tazima	B. B. Kadomtsev B. N. Kolbasov V. I. Pistunovich
USA	EC
W. M. Stacy (Vice-Chair) J. R. Gilleland G. L. Kulcinski P. H. Rutherford	G. Grieger F. Engelman D. Leger R. Hancox R. Verbeek (Secretary)
IAEA	
J. A. Phillips V. S. Vlasenkov	

3. Fruits of the workshop

Finally the INTOR workshop continued for 10 years till 1988. The workshop played a role to establish international partnership in fusion research. S. Mori took a leadership for all these periods, which raised the status of Japanese fusion research among international fusion research community. The design parameters had been changed step by step, but the machine size was kept compact throughout the period, which was the principal policy of the steering committee. They thought that the size and thus the cost of the machine have to be limited from the viewpoint of commercial purpose. It is important to note that the workshop activity became a basis of the international collaboration framework in fusion research such as the ITER (International Thermonuclear Experimental Reactor) project, although the INTOR machine itself was not constructed. On the other hand, it is also noted that the successful international collaboration was due to the preliminary stage of fusion research as a commercial energy development, where international friction caused by national interest of each country was not apparent. It will not be promised in future when fusion energy approaches commercial reality.

References

[1] Workshop Report by S. Mori, 1978, NIFS FSA.
[2] Workshop Report by K. Saco and T. Tazima, 1979, NIFS FSA.
[3] Interview to S. Mori, March 10, 2011, to be registered as NIFS FSA.