§10. Studies on History of Nuclear Fusion Research at the Dawn Stage

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This report summarized the results of our research on history of nuclear fusion research carried out by the joint research program of CST Nihon University and NIFS Fusion Science Archives. These results were based on examining the historical documents that are kept in NIFS Fusion Science Archives and so on. In this fiscal year, we studied 1) History of Tihiro Ohkawa's nuclear fusion research on D.C.Octopole, 2) Comparison of performance of machines in reports about the Third International Conference on Plasma Physics and Controlled Nuclear Fusion Research.

1. History of Tihiro Ohkawa's nuclear fusion research on D.C.Octopole

Tihiro Ohkawa is one of the most famous persons among Japanese nuclear fusion researchers. We investigated nuclear fusion research on D.C.Octopole by Ohkawa and Gulf General Atomic (GGA) multipole group from 1960's to 1970's. Ohkawa and GGA nuclear fusion research group constructed the D.C.Octopole device around 1968-69. This machine was built to investigate whether the confinement time of a few tens of Bohm diffusion times observed in the devices in 1960's represented an absolute upper limit on the confinement time.

The plasma confinement time in the D.C.Octopole was 300 times longer than the Bohm time in 1969's experiments. In addition, the classical diffusion in a toroidal device was observed for the first time. These results were presented at International Symposium on Closed Confinement System held in 1969 by T.Ohkawa, M.Yoshikawa et al. After that, in order to see toroidal effects on the diffusion, the toroidal magnetic field was added to the device. The experimental result was explained, for the first time, by the neoclassical theory. Thus, the original purpose of D.C.Octopole's experiments, the revival of plasma confinement time in a toroidal device, was achieved successfully.

In the 1970s, D.C.Octopole was used to investigate the behavior of Ohmic heating discharge in a noncircular cross-section tokamak with poloidal diverters and the effects of RF heating of ions on plasma confinement. The experimental purpose of D.C.Octopole was gradually changed from research of plasma physics to nuclear fusion engineering, which led to Doublet-II (a tokamak with non-circular cross section) that was constructed in 1972.

2. Comparison of performance of machines in reports about the Third International Conference on Plasma Physics and Controlled Nuclear Fusion Research

The Third International Conference on Plasma Physics and Controlled Nuclear Fusion Research was held at Novosibirsk in U.S.S.R. in 1968. Conference reports and trip reports are available by participants from major countries. We investigated contents of conference reports of Japan, the USA, U.S.S.R. and the U.K. and compared the comments on performance of stellarator, multipole and tokamak.

(1) Stellarator: R.J.Bickerton and A.Gibson (Culham Lab.) mentioned that many of stellarator experimental results were located within a factor of about 10 of the classical time. Koji Uo (Kyoto Univ.), B.B.Kadomtsev (Kurchatov Inst.) and H.P.Furth (LRL) placed the result of Wendelstein-II (Max-Planck Inst.) with barium plasma as the main result of this conference. On the other hand, L.A.Artsimovich (Kurchatov Inst.) commented that this result wasn't applied to high temperature plasma experiments.

(2) Multipole: Artsimovich reported in the conference summary talk that multipole devices were concluded not to arrive at a practical nuclear fusion reactor and it would take a considerable time to obtain the experimental results of prospective superconducting multipole. Based on Artsimovich's summary talk, T.K.Allen (Culham Lab.) commented that the next generation of multipole devices should be designed to extend the experimental time, to avoid or minimize support losses, and to minimize electric field effects. However, Furth summarized as follows: the present-day multipole experimental condition was quite primitive, but new experiments incorporating improvements were underway in USA.

(3) Tokamak: Tokamak T-3 in U.S.S.R exceeded 30 times of Bohm diffusion limit. This result was mentioned by Kadomtsev, R.L.Hirsch (US.AEC) and Masatoshi Tanaka (JAERI) et al. Hirsch reported that Artsimovich introduced with pride the present state of the tokamak. On the other hand, Furth and H.A.B.Bodin (Culham Lab.) mentioned that there were still a number of unanswered questions for the results of T-3: for example, equilibrium, anomalous electron heating, electron runaway and so on. Immediately after the conference report was written, USA and U.K researchers were still suspicious about the results of tokamak of the U.S.S.R.

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