4. Network-Type Collaboration Research

This research is eligible for study conducted by collaborating with facilities owned by NIFS and multiple universities. In this fiscal year, the research shown below was done. The titles and brief summaries of the research topics are listed below.

(1) Study of suppression and avoidance of vertical position shift phenomena in tokamaks using three-dimensional magnetic fields T. Fujita (Nagoya University)

In this study, we investigate methods to suppress and avoid vertical displacement (VDE), which is a problem in tokamaks, using a three-dimensional magnetic field from both experimental and theoretical perspectives. In tokamaks, high beta and confinement performance can be obtained by increasing plasma cross-sectional noncircularity (longitudinal elongation), but the vertical position tends to be unstable in highly noncircular plasmas, and stabilization of the vertical position (suppression of VDE) is an issue. It is theoretically predicted that the application of a helical magnetic field (three-dimensional magnetic field) can stabilize the vertical position, and this has been confirmed in several experiments. It would be more practical if this could be realized using local coils with simple layout and geometry. Therefore, plasma position stabilization experiments using 3D magnetic fields generated by local coils have been conducted in the TOKASTAR-2 system at Nagoya University and the PHiX system at Tokyo Institute of Technology. In previous studies, the strength condition of the 3-D magnetic field required for position stabilization was described by a rotational transformation of the 3-D magnetic field, but the transformation is not suitable for local coils because they do not necessarily form closed magnetic surfaces. A new index is needed to replace the rotational transformation. Therefore, the goal of this study is to create an identical index that can describe the stabilization conditions in the two devices with different local coils.

In addition, the interaction between a resonant perturbation magnetic field (RMP) and plasma, which is one of the three-dimensional magnetic field applications to confined plasmas, will be tested in the HYBTOK-II device at Nagoya University and in the LHD at the National Institute for Fusion Science, to establish a theoretical model of RMP propagation and a method to control peripheral MHD instabilities by RMP.

One of the objectives of this research is to support and stimulate experimental research on MHD equilibrium and stability in university laboratories through education for students by conducting this work mainly on small experimental devices at universities.

(2) New Developments in CT-derived Technologies for Space and Planetary Magnetospheric Plasma Science N. Fukumoto (University of Hyogo)

Spheromak (Spk) and field reversal coordination (FRC), which are called compact torus (CT) plasmas, have been applied to plasma collision/coalescence, injection, and irradiation in the field of fusion research, taking advantage of their features such as high density, high beta, and portability. This study aims to expand the CT-derived technology obtained in fusion research to interdisciplinary research. For example, Spk is used for planetary magnetospheres and space propulsion, and FRC is used for collisionless shock waves generated in space. Furthermore, through a comprehensive discussion of the results obtained in this research, we aim to share and promote new knowledge and research on high-beta plasma physics, etc., and to strengthen development capabilities by sharing information on equipment technology, such as continuous injection of magnetized coaxial plasma guns (MCPG) and improvement of injection performance. Interdisciplinary research topics with strong relevance have been proposed in the units of the National Institute for Fusion Science, and they are expected to contribute to the progress of such research.

(3) Study on tritium, radon, and radium concentrations and dynamics of tritium, radon, and radium in environmental water in Japan T. Sanada (Hokkaido University of Science)

In order to clarify the dynamics of tritium in the environment of Japan, which has a long geographical feature from north to south, it is necessary to understand the tritium concentration in various regions through a wide-area field survey.

In this study, the National Institute for Fusion Science, which has a tritium precision measurement system, is the core of a network established by several research institutes to continuously observe tritium concentrations in environmental water over a wide area. In addition, we will also observe radon-222 Rn and radium-226 Ra, which are naturally occurring radionuclides, and investigate their usefulness as tracers of the causes of concentration fluctuations. Furthermore, these activities will be positioned as training for graduate students in the measurement and analysis of tritium and radon in water to foster young researchers in this field.

(4) Comprehensive study of hydrogen isotope behavior in plasma-facing walls for fusion reactors through inter-university collaboration Y. Oya (Shizuoka University)

In order to predict tritium behavior in future fusion reactors such as DEMO, it is efficient to conduct a systematic evaluation of hydrogen isotope behavior by effectively utilizing large plasma devices in the operation, small plasma devices in laboratories, and analytical instruments owned by each university.

In this study, W and W-10%Re alloys and their irradiation-damaged samples are prepared as common examples. These samples are used in experiments at each university and evaluated to obtain systematic knowledge. Physical constants related to hydrogen isotope behavior, which are necessary for DEMO reactor design, will be clarified. This study can contribute to understanding the hydrogen isotope behavior in JT-60SA and ITER.