9th Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

Design and assembly of internal-coil divertor experimental device SOLEIL

KIZU Hisato, FUJITA Takaaki, OKAMOTO Atsushi, KAWACHI Yuichi, KAMBARA Shungo
Nagoya University
kizu.hisato.x9@s.mail.nagoya-u.ac.jp:

In fusion reactors, there is concern that impurity ions injected to reduce the load on divertor plates may lead to a decrease in fusion power. To investigate the effects of the plasma cross-sectional shape on plasma flow and impurity transport in the scrape-off layer, an experimental device called SOLEIL (Scrape Off Layer Experiment with Internal coiL) has been developed. The feature of this device is to form tokamak-like magnetic field configurations using an internal ring coil. In this device, by applying appropriate currents to each coil, it is possible to form divertor configurations with various shapes.

SOLEIL has an axisymmetric structure, and a conceptual cross-sectional view is shown in Fig. 1. A center post is installed at the center of the device, through which 56 central conductors of the toroidal field (TF) coils pass. The return section of the TF coils has 8 legs and is demountable. The rated TF coil current is 1.41 kA (78.8 kA·T) to generate a magnetic field of 0.0875 T for electron cyclotron resonance of 2.45 GHz microwave at the position of the internal coil. The internal coil that simulates plasma current is protected by a SUS cover and is supported by eight SUS rods with a diameter of 1.5 mm connected to the center post. Each support rod is covered with an alumina pipe with a diameter of 3 mm, Plasma generation and heating are carried out using microwaves at 2.45 GHz. The planned plasma duration is approximately 100 ms, and inertial cooling is adopted for the coils.

In the design of the internal coil and support rods, it was intended to minimize plasma losses due to contact with them. The shape of the internal coil was optimized using a magnetic field calculation code for axisymmetric coils.

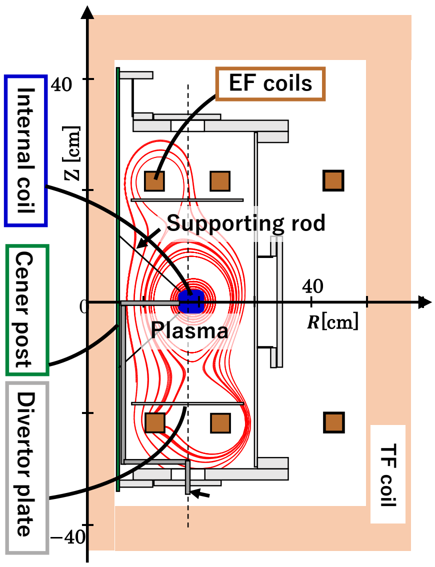

Fig. 1 : The conceptual cross-sectional view of SOLEIL

The goal was to minimize the innermost closed magnetic surface that does not contact the coil. As a result, it was found that the optimal cross-sectional shape for the internal coil is a square with the inner corner on the major radius side shaved off. The final design of the internal coil has a major radius of 180 mm, a conductor diameter of 2 mm, and 285 turns, capable of carrying approximately 8 kA·T of current. Three pairs of equilibrium field (EF) coils are installed on the upper and lower sides of the device; two pairs inside the vacuum vessel and one pair outside the vessel. With magnetic field calculations, it was confirmed that divertor configurations with varying triangularity and numbers of null points can be formed by adjusting the currents in the EF coils.

Assembly work began in May 2024 and was completed in January 2025. In February 2025, the first plasma was successfully generated by energizing only the TF coils and injecting microwaves. The working gas used was Ar, with a pressure of 2.2×10^{-2} Pa. Light emission due to resonance was observed through high-speed camera imaging. Subsequently, plasma generation experiments using the internal coil and EF coils were conducted, and the formation of a ring-shaped plasma around the internal coil was observed. Figure 2 shows a photo in that experiment.

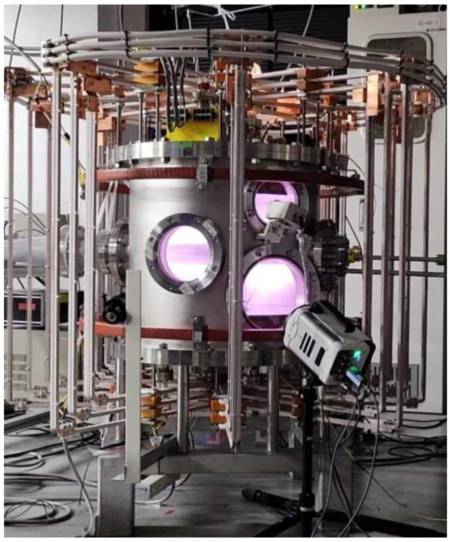

Fig. 2 : The plasma of SOLEIL with internal coil and EF coils

In the future, diagnostic systems for probe-based and spectroscopic measurements will be established. Simultaneously, magnetic surface mapping using fluorescence induced by an electron gun will be performed to examine the magnetic field structure, which will be compared with numerical predictions.

The work has been supported by JSPS KAKENHI Grant No. 23K22473 and NIFS collaboration research program Grant No. NIFS25KIPF021.