4. Basic, Applied, and Innovative Research

As an inter-university research institute, NIFS activates collaborations with researchers in universities as well as conducting world-wide top level researches. The collaboration programs in basic, applied, and innovative research support research projects motivated by collaboration researchers in universities. It is also important to establish the academic research base for various scientific fields related to fusion science and to maintain a powerful scientific community to support the research. Programmatic and financial support to researchers in universities who work for small projects are important.

For basic plasma science, NIFS operates several experimental devices and offers opportunities to utilize them in the collaboration program for university researchers. A middle-size plasma experimental device the HYPER-I is prepared for basic plasma research. The compact electron beam ion trap (CoBIT) for spectroscopic study of highly charged ions, atmospheric-pressure plasma jet devices for basic study on plasma applications, and other equipment are operated for collaborations.

(I. Murakami)

Simulations of negative ion extraction and transport for developing novel remote reactive ion processing system

A novel remote dry processing of specific reactive negative ions with a deflection and focusing system is being developed to precisely control their energy, flux and reaching position on the nanoscale. The trajectory simulations of the negative ion extraction and transport for the design of this processing apparatus have been carried out using SIMION software. It is found from the simulation results that the ion beams with good focusing characteristics, high directivity and appropriate current amount can be successfully extracted from the plasma source and transported to the reactor chamber through the deflection and focusing system. A typical result for the case of negative oxygen ions is shown in Fig. 1. As recognized from trajectories of O^- ion beams, the extraction and transport characteristics of the flat intermediate electrode are superior to those of the oblique one [1].

(T. Kanki, Japan Coast Guard Academy and H. Himura, Kyoto Institute of Technology)

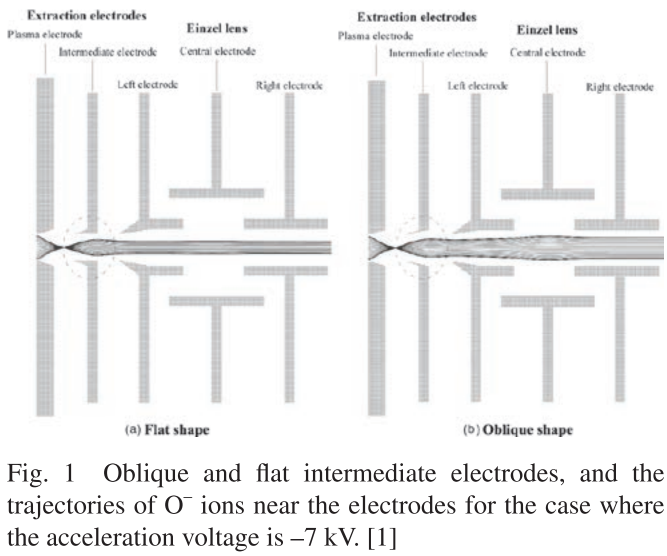

Fig. 1 Oblique and flat intermediate electrodes, and the trajectories of O^- ions near the electrodes for the case where the acceleration voltage is –7 kV. [1]

Toward the understanding of transport and self-organization mechanisms of flowing plasmas

Precise measurements of flow and potential structures are essential for the understanding of transport and selforganization phenomena commonly observed in various plasmas. For this purpose, development studies on a compact heavy ion beam probe (HIBP) system and coherence imaging system (CIS) are conducted for the RT-1 magnetospheric experiment. Based on the detailed analysis of laser irradiation conditions, a laser ion source was developed to provide a high brightness multi-charged beam for the HIBP system [2]. For the two-dimensional measurements of ion temperature and flow, a CIS system with a new CIS cell and electron multiplier CCD (EM-CCD) was developed, installed, and operated at the RT-1 (Fig. 2). For the calibration of wavelength, a new technique, using spectral line sources, was proposed as a reliable absolute calibration method [3]. Initial measurements in the RT-1 showed that the flow profiles are not simply explained by the grad-B and curvature drift in a dipole magnetic field especially in a strong field region, suggesting the existence of radial electric field in high-beta plasmas.

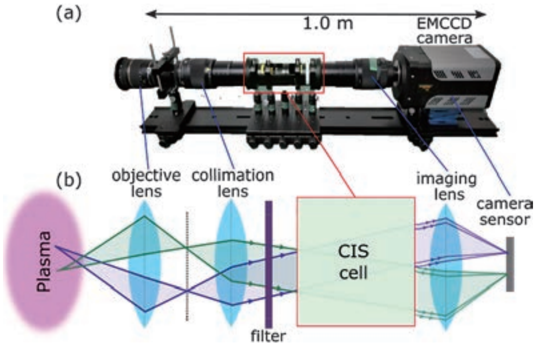

Fig. 2 CIS system for the 2-d measurements of ion temperature and velocity in RT-1 [3].

(H. Saitoh, Univ. Tokyo)

A broadband mid-infrared source for remote sensing

Fiber-optic sensors based on MIR absorption spectroscopy have great potential to be the next-generation gas detecting device. However, there is the remaining issue of the absence of a suitable MIR source exhibiting broadband spectrum and high-beam quality. In this work, the research team has demonstrated an ultra-broadband light source at the MIR region, which meets the requirements for developing the fiber-optic sensor. Er^{3+}/Dy^{3+} co-doped ZBLAN optical fiber has been used to obtain broadband mid-infrared (IR) light sources pumped by commercially available laser diodes [4]. The demonstration shows that mid-infrared broadband emission, extending from 2515 to 3735 nm, was obtained by energy transfer between Er^{3+} and Dy^{3+}, as shown in Fig. xx. To assess its potential for gas sensing applications, the fabricated light source was used to detect methane gas with concentrations at 1% and 5%. We can then say that the simple and stable construction of our light source is suitable for practical purposes.

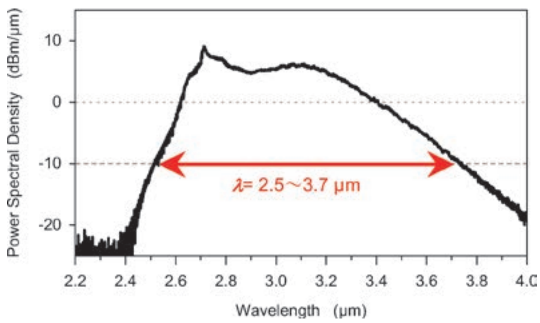

Fig. 3 Power spectral density of the developed MIR source.

(K. Goya, Akita Prefectural Univ.)

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[3] K. Ueda *et al.*, Rev. Sci. Instrum. **92**, 073501 (2021).
[4] K. Goya *et al.*, Scientific Reports **11**, 5432 (2021).