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Development of OES methods for diagnostics of the plume region of electric thrusters

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I. Introduction

With the diversification of space missions, new requirements are putting forward for the propulsion system, which promotes the rapid development of a variety of new electric propulsion (EP) systems. A new propulsion system needs thousands hours' of ground tests and optimization before it can be used in space mission. During this time, it is important to master efficient and reliable plasma diagnostic method for accelerating the iterative process of system optimization.

Optical emission spectroscopy (OES) is a non-invasive diagnostic method, which have complementary advantages with electric diagnostic method such as Langmuir probe [1]. It can overcome the interference of electric and magnetic field, which is common in EP systems. Besides, by combining with imaging or tomography technology, the 2D/3D distribution of plasma parameters could be obtained, which is highly valuable in optimization of EP systems.

In this presentation, a novel OES method is presented, which can determine electron density (n_e) by using Xe ionic and atomic spectral lines. Sensitivity analysis of spectral lines to plasma parameters is carried out to determine the appropriate spectral lines, and the source of diagnostic errors is discussed. Several demonstrations is presented. Besides, an attempt to obtain 2D parameter distribution is also introduced, by combining OES method with imaging technology [2].

II. Method

Based on a comprehensive collisional-radiative (CR) model of Xe ionic and atomic species [3-4], we analyzed the parameter dependence of atomic and ionic spectral lines that have good signal-to-noise ratio in the EP plasma. From which we find that the line ratio of ionic 484.433 nm line and atomic 992.320nm line is sensitive to n_e in the parameter range of the hollow cathode (HC) and ECR micro-thruster plume used in this work. The analysis of parameter sensitivity and kinetic mechanism behind the parameter dependence will be described in detail in this presentation. These lines are then used to determine n_e from emission spectra. In addition, a Langmuir probe is used to obtain the plasma parameters simultaneously.

III. Results

Experiments are performed in the magnetized plume of a hollow cathode and the plume region of an ECR micro-thruster. Spectroscopy and Langmuir probe measurements are carried out under three different magnetic field configuration of the magnetized plume, which are cusped field, diffused field and non-magnetic field, respectively. The sight view of the optical probe is along the radial direction, while the Langmuir probe is placed on the axial line of the plumes to minimize the interference of magnetic field. Both the Langmuir probe and the optical probe are mounted on a positioning system powered by a stepping motor, to obtain spatial resolved signals along the axial direction. Take it by and large, the result obtained by OES method and the Langmuir probe are in agreement with each other. And the n_e of the magnetized HC plume is about $1\times10^{11}\sim6\times10^{11}$ cm^{-3}.

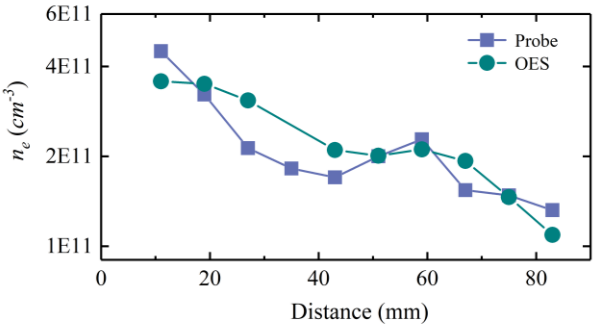

Figure 1 Electron density distribution of the cusped-field HC plume.

Figure 1 shows the n_e distribution in the HC plume which has a cusped magnetic field configuration. Since there is a ring-magnet at the fourth measuring point, emission spectrum is not measured and no OES result is obtained here. However, the Langmuir probe is along the axial line and is unaffected by the problem. A detailed description of the diagnostic method will be given in the presentation, as well as an attempt to obtain 2D parameter distribution of the plume region.

IV. Discussion

The electron energy distribution function (EEDF) form is found to have an effect on the line ratio dependence of plasma parameters, which may affect the diagnostic results. The effect of EEDF as well as some other problems will be discussed in detail in the presentation.

References

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