Self absorption effect of He resonance line on visible line spectrum

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The emission spectrum analysis is widely used to estimate electron temperature and density non-invasively, which are important parameters for determining plasma properties. Among these techniques, helium emission spectra are frequently utilized because the emission properties of helium have been well studied.[1,2] The visible spectrum produced when helium gas is sprayed on a plasma can be analyzed to diagnose high-density plasmas up to about 100 eV. A mechanism that hamper accurate estimation of the plasma parameter is the self-absorption of the resonance lines, since the self-absorption process can excite the neutral atoms around the plasma and can modify the intensity of the visible line spectrum.[3]Therefore, it is necessary to quantitatively evaluate the effects of self-absorption around the plasma in order to accurately estimate the plasma parameter through visible line spectrum analysis technique.

To experimentally elucidate the self-absorption strength and impact on the visible line spectroscopic technique, we developed a VUV spectroscopy system which can remotely vary the absorption length in the vacuum vessel (Fig. 1). The vacuum ultraviolet spectrometer used has a focal length of 1 m and a grating of 1200 grooves/mm, enabling observation in the range of 49.9 nm-61.1 nm using X-ray CCD. A collimator with an inner diameter of 5 mm is placed between the spectrometer and the plasma to determine the solid angle observed by the spectrometer. An Al filter is installed between the collimator and the plasma to eliminate visible and to maintain the difference between the pressure in the vacuum vessel (1-10 Pa) and the pressure in the spectrometer (-10^{-4}Pa). Therefore the Al filter's pressure barrier performance limits the area where self-absorption occurs between the plasma and the Al filter. The observation window with the Al filter is attached to an actuator. Therefore, the length of the line-of-sight where self-absorption occurs can be changed arbitrarily in the range of 50-160 nm by moving the actuator.

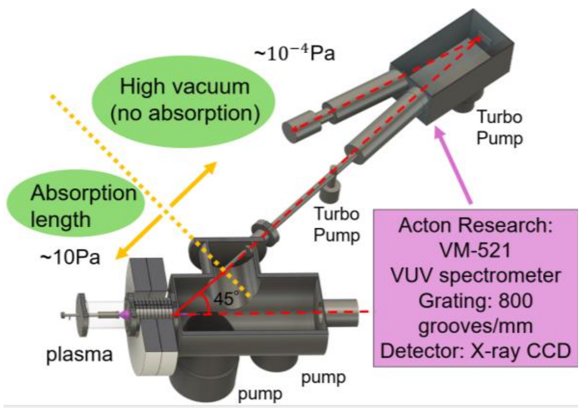

Figure 1 Schematic diagram of the plasma source and the VUV spectroscopic system.

Figure 2 shows the relationship between the absorption length and the emission intensity of the resonance line(58.4nm). The emission intensity is normalized so that the intensity when the observation window is placed 50 mm from the plasma to be 1.

Figure 2 shows that the intensity of the emission decreases with increasing the self-absorption length. This result experimentally indicates that the self-absorption is significant outside the plasma, and suggests that the emission of neutral particles around the plasma can affect the visible spectrum used for plasma diagnostics.

In this presentation, we will experimentally evaluate the relationship between absorption length and plasma parameters obtained by Thomson scattering and Stark spectroscopy, and the effect of changes in absorption length on the intensity of the He visible spectral lines.

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References

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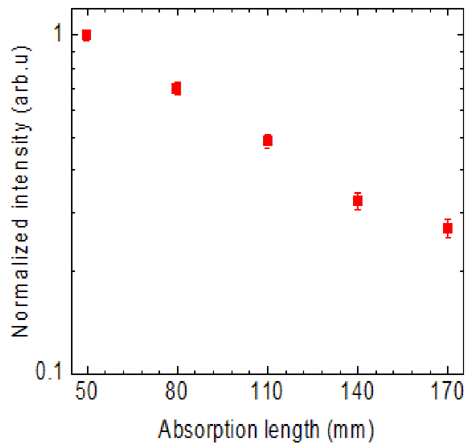

Figure 2 The dependence of helium resonance line intensity on the length of the absorption region.