# Calculation of the Tangential View of an H-Alpha Intensity Profile in the Large Helical Device


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# Calculation of the tangential view of an H-alpha intensity profile in the Large Helical Device

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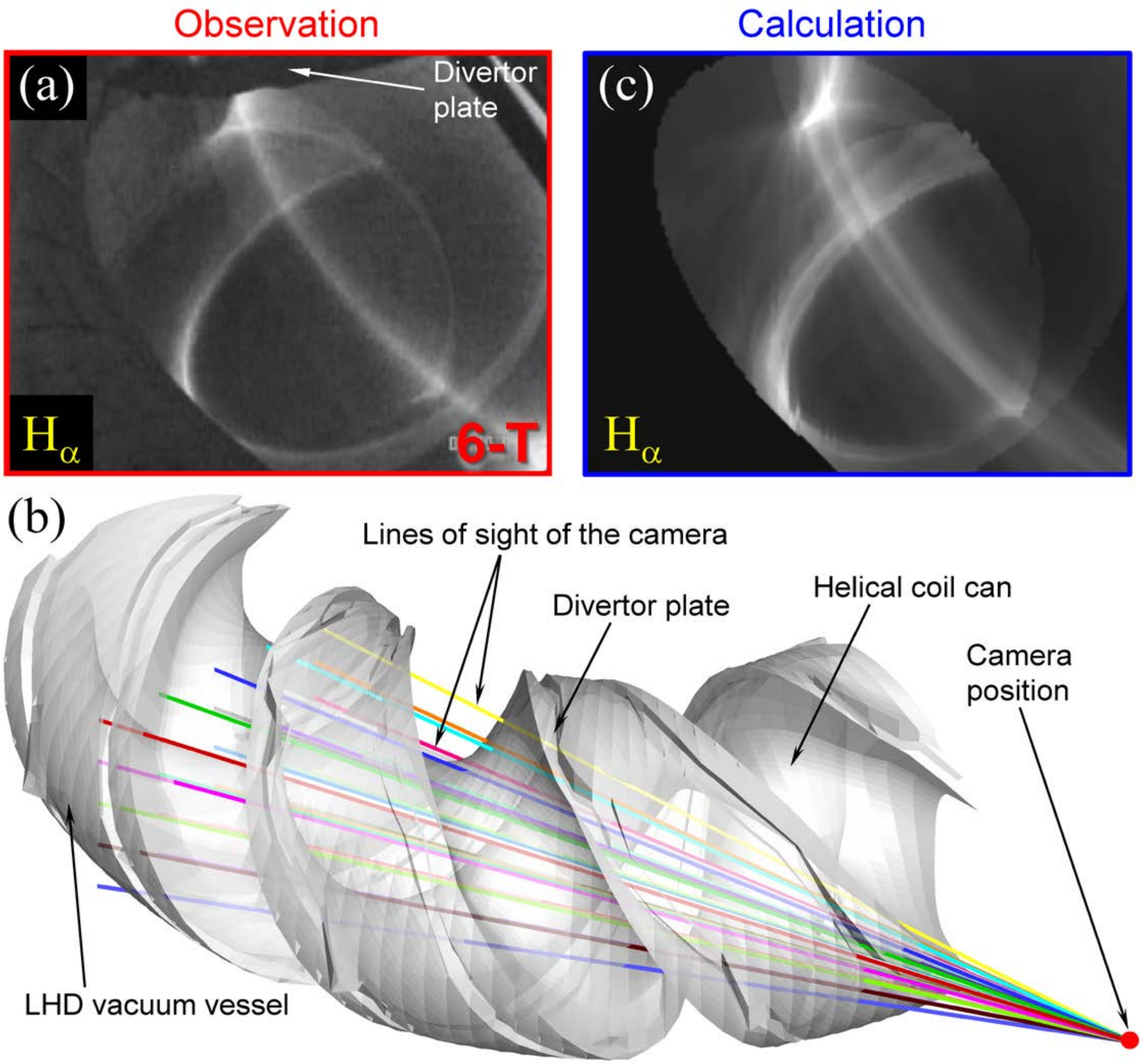


Fig. 1. A tangential view of the H-alpha intensity profile of a LHD plasma observed with a CCD camera (a). Three-dimensional grid model for neutral particle transport simulation for a LHD plasma geometry (b). A calculated image of the tangential view of an H-alpha intensity profile calculated by a three-dimensional neutral particle transport simulation code in a LHD plasma (c).

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***Abstract* – A tangential image of a H-alpha intensity profile in a LHD plasma is investigated by a neutral particle transport simulation using a detailed three-dimensional grid model including the geometry of the helical plasma and the vacuum vessel. The calculated image of the H-alpha intensity profile calculated by the simulation quite agrees with the observed image, which strongly suggests that there is no significant abnormal neutral particle sources in typical plasma discharge operation in LHD.**

Large Helical Device (LHD) is the world's largest super-conducting heliotron type machine which consists of two twisted helical coils and three pairs of circular poloidal coils for plasma confinement [1]. Helically twisted plasmas are produced by magnetic field configurations formed by the two super-conducting magnetic coils. Tangentially viewing visible CCD cameras (SONY DXC-LS1) have been installed for monitoring LHD plasmas and plasma-wall interactions in the vacuum vessel. Figure 1(a) is an observed tangential image of an H-alpha intensity profile in the case of typical magnetic configuration (the radial position of the magnetic axis $R_{ax}$=3.60m). Bright winding zones are observed by line integration from a tangential port (6-T) through the three-dimensionally complicated shaped plasma in LHD.

For interpreting the structure of the bright zones, an analysis using a fully three-dimensional neutral particle transport simulation code (EIRENE) was performed [2]. Figure 1(b) illustrates the aerial view of the three-dimensional grid model of the LHD plasma, the vacuum vessel and divertor plates for three toroidal pitch angles ($0<\phi<108°$). The grid model includes some components installed in the vacuum vessel as precise as possible. Colored straight lines indicate representative 25 lines of sight of the H-alpha filtered camera installed in the tangential port. The image of the H-alpha intensity profile is calculated by integrating H-alpha emission along the lines of sight. The pivot point of the lines of sight corresponds to the position of the camera. The range for the integration is restricted to that between the first two intersections with the vacuum vessel, which is started from the pivot point.

The neutral particle transport simulation gives the three-dimensional profile of H-alpha emission in the grid model, showing localized emission in the plasma periphery. The emission is calculated by using the plasma density/temperature and the neutral particle (hydrogen atoms and molecules) density, which bases on calculations by the collisional-radiative model. The most important factor determining the spatial profile of the neutral particle density is the toroidal/poloidal distribution of the neutral particle source. In this simulation, the particle source is distributed on the divertor plates, and abnormal neutral particle sources on the vacuum vessel or helical coil cans is NOT included. The particle source distribution is given by ion flux distribution from the main plasma to the divertor plates. The plasma parameters in the main plasma are calculated by a three-dimensional plasma fluid code (EMC3-EIRENE) in typical LHD plasma parameter condition (average plasma density $<n_e>\sim5\times10^{19}m^{-3}$) [3]. A one-dimensional plasma fluid analysis along magnetic field lines on divertor legs gives the ion flux distribution, basing on the calculation of the ion flux distribution from the main plasma by the EMC3-EIRENE. The analysis indicates that most of the neutral particle sources locate on the divertor plates installed in the inboard side of the torus for this magnetic configuration ($R_{ax}$=3.60m).

The calculated tangential image of the H-alpha intensity profile is illustrated in Figure 1(c). This image is made of line-integrated H-alpha intensities along totally 161×161 lines of sight. The tangential image quite agrees with the observed one shown in Figure 1(a). It reproduces the structures of the bright winding zones and the intensity profile. Line integrated intensity profiles observed with multichannel H-alpha emission detector arrays installed on two poloidal planes, on which the LHD plasma is horizontally/vertically elongated, also agree with the profiles reconstructed by the line-integrated H-alpha intensities calculated by the simulation code [4]. It clearly shows that the bright winding zones originate from the H-alpha emission in the LHD plasma periphery. The consistency between the observation and the calculation strongly suggests that no significant abnormal neutral particle sources in the case of typical plasma discharge operation in LHD.

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