Bolometric Imaging of Radiative Structures on the Large Helical Device

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1. Introduction

The infrared (IR) imaging bolometer (IRIB) is a new type of plasma radiation measurement system, which uses an IR camera [1, 2]. The IRIB uses a foil sandwiched between two identical masks to absorb the plasma radiation. The increase in the foil temperature due to the radiation is measured with an IR camera. The key feature of the IRIB is that using readily available IR imaging technology, a measurement of 2-dimensional spatial radiation profiles is very easy. Previously two types of IRIB ware tested on the Large Helical Device (LHD) which are the Segmented Mask Imaging Bolometer (SIB) [3] and the Infrared Imaging Video Bolometer (IRVB) [4]. In this paper we demonstrate the ability of the IRVB to display the helical structure of the plasma radiation in LHD by comparing an IRVB image with a corresponding image of CIII light and the structure of the chaotic magnetic field lines in the ergodic region.

2. IR Bolometer system on LHD

The Large Helical Device(LHD) is a large-scale superconducting heliotron system with a set of l/m =2/10 helical coils [5]. The data shown in this paper comes from a discharge with the parameters R_{axis} = 3.6 m, B_t=2.88 T, and $n_e = 9 \times 10^{19}/m^3$. The IRVB used in this study provides a 10 x 14 pixel image of the plasma radiation with a sensitivity of 0.5 mW/cm^2 and a time resolution of 67 ms [4]. Figure 1 shows the field of view (FOV) of the IRVB installed at a tangential port on LHD. The yellow line indicates the horizontally elongated cross-section and the red line shows the more distant vertically elongated cross-section. The light blue rectangle shows the FOV of the IRVB determined from the pinhole position and size of

the foil. The FOV is slightly blocked by the vacuum vessel and another diagnostic shown in black and light blue. Comparison with the IRVB emissivity image in Fig. 2 shows plasma radiation coming from the unblocked portions of the FOV.

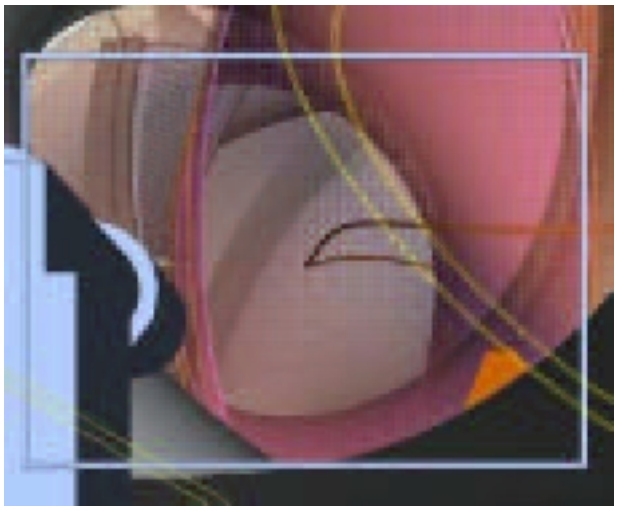

Figure 1 CAD drawing of field of view(inside blue line) of IRVB at tangential port on LHD.

3. Comparison of edge magnetic field lines and IRVB data

In the absence of heavy impurities the radiation profiles should be hollow and the bulk of the radiated power should come carbon radiating from the ergodic region of the plasma outside the last closed flux surface. Figure 3 shows the field line calculation as viewed from the tangential port on LHD [6]. Each blue point indicates a field line launched in the region just outside the last closed magnetic surface ($\rho = 1$). Therefore brighter blue regions indicate regions where the IRVB has a more

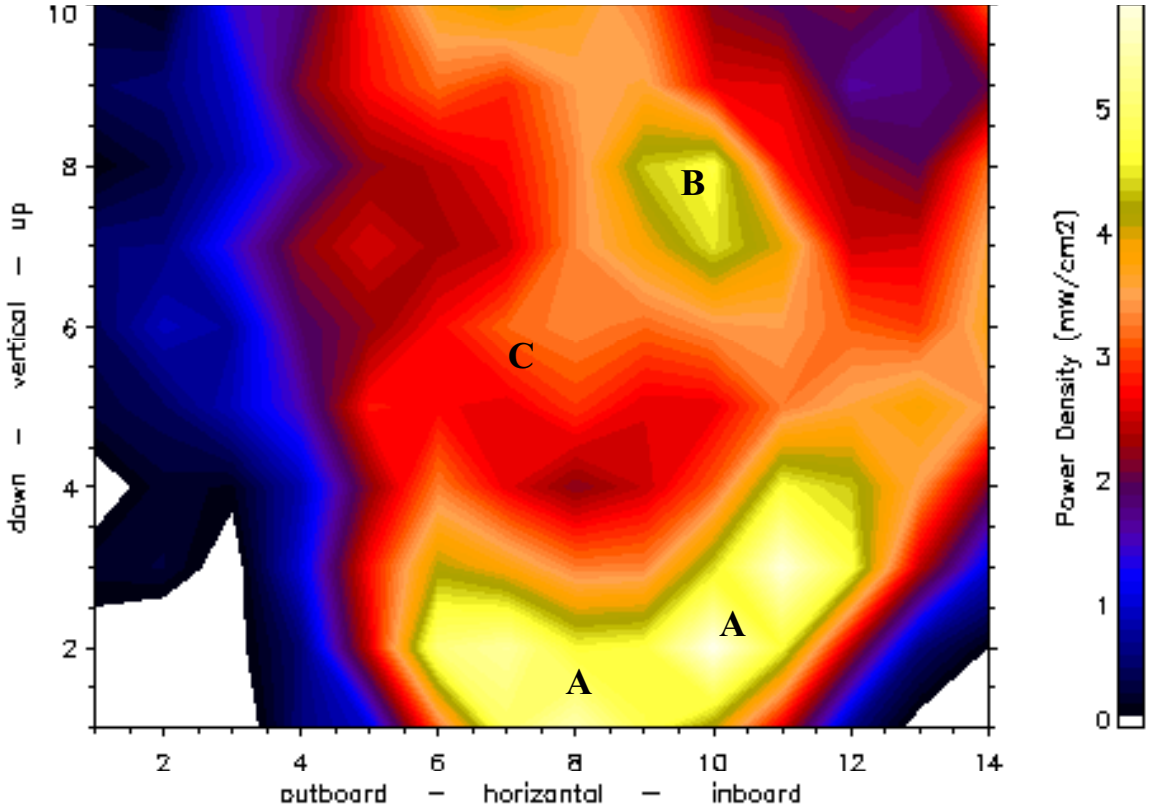

Figure 2 Image of two-dimensional radiation from tangentially viewing IRVB at t = 0.99 s for LHD shot # 20744.

tangential view of the edge chaotic region and should correspond to areas of more intense radiation. However the effects of solid angle are not included in the calculation, therefore the portions of the plasma which are far from the detector and would radiate less brightly are given the same weight as those near the detector that radiate more strongly. But Fig.3 very clearly shows the helical structure of the chaotic edge region as viewed by the IRVB.

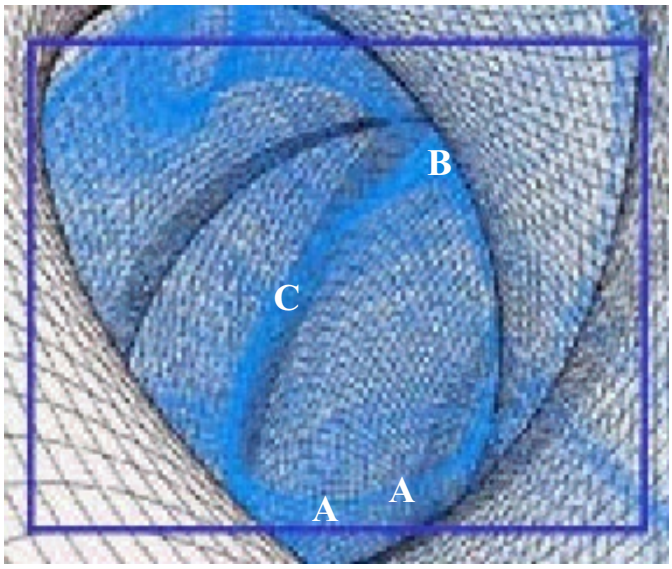

Figure 3 Magnetic field lines (light blue) in the ergodic region (with IRVB field of view indicated by dark blue line) .

Comparison between the IRVB data and these magnetic field lines shows the strong helical structure of the plasma radiation predicted by the magnetic structure. In particular the broad radiative structure observed in the lower portion of the field of view (indicated by A) is very bright partly due to the fact that it lies in the near field of the IRVB. The bright region in the upper portion of the IRVB image corresponds to the location where two dense regions in the magnetic field line calculation overlap as indicated by point B. The structure seen in the center of the field of view in Fig. 3 (indicated by C) is not so clear in the IRVB image in Fig. 2, which may be understood by comparison with the image from a CCD camera filtered for CIII radiation.

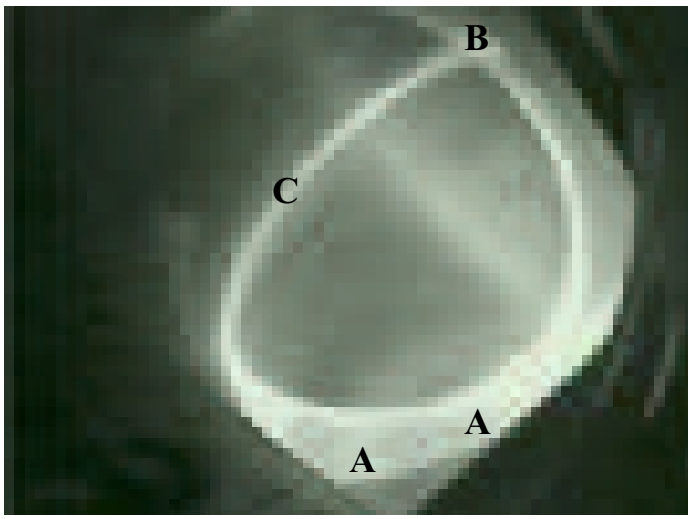

Figure 4 Image of CIII radiation from tangentially viewing CCD camera at t = 0.99 s for LHD shot # 20744.

4. Comparison of the imaging bolometer data and the CIII radiation image

A simultaneous image from a CCD camera using a CIII filter and having nearly the same view of the

plasma is shown in Fig. 4. Since carbon is the main impurity and mainly radiates from the edge, it should give an image similar to that of the IRVB. Comparison of the images shown in Figs. 2 and 4 show very similar features. The structures indicated by A and B are both clearly seen in both images. However the structure indicated by C is not so clear in the bolometer image as was mentioned above. This may be due to the thinness of the structure and the relatively poor spatial resolution of the IRVB compared to the CCD camera.

5. Summary

Good qualitative agreement is observed in the comparison of the bolometric image with a corresponding image from a CCD camera filtered for CIII light and with the magnetic field lines of the chaotic edge region outside of the last closed magnetic surface. This demonstrates that the IRVB can clearly show a two-dimensional image of the three-dimensional helical structure of the radiation from LHD. The next step in this research and development program is to carefully calibrate, install and bring into operation two additional imaging bolometers at upper and lower ports viewing the same plasma volume as that seen with the tangential IRVB. The data from these three imaging bolometers will then be used to attempt the first three-dimensional tomography of plasma radiation.

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