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Characteristics of toroidally asymmetric behavior of divertor heat load related to three-dimensionally localized radiation structure in impurity seeded plasmas on LHD

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In fusion reactors, huge power exhaust toward divertor region is mitigated by divertor detachment using impurity seeding. Although divertor heat load reduction in all toroidal sections is preferable, toroidally asymmetric heat load reduction was observed in various toroidal devices. The asymmetry is caused by the localization of the radiative cooling. While the measurement of the localized radiation structure is required for the detailed investigation of the asymmetry, toroidal arrays of resistive bolometers [1] and/or divertor Langmuir probes [2] is generally used to speculate the asymmetry.

In this study, the three-dimensionally localized structure of the radiative cooling was extracted [3] using Principal Component Analysis (PCA) from two-dimensional radiation images measured with an InfraRed imaging Video Bolometer (IRVB) [4, 5]. The IRVB has 520 channels (26 in toroidal and 20 in radial). Typical two-dimensional radiation images in nitrogen (N_2) seeded plasmas with toroidally-asymmetric heat load reduction and in neon (Ne) seeded plasmas with toroidally-symmetric heat load reduction are shown in Figure 1 (a) and (b), respectively. It is difficult to discuss the difference between the images through direct comparison. Therefore, PCA was applied to 34 images each in N_2 seeded plasmas and in Ne seeded plasmas. As the result, a radiation feature in N_2 seeded plasmas was found as one of the principal components as shown in Figure 1 (c). The three-dimensional transport code EMC3-EIRENE indicated that the ionization in one of the divertor legs is enhanced in nitrogen seeding compared with Ne seeding due to the difference in the first ionization energy. The magnetic field lines from the divertor leg were along the extracted radiation structure and were terminated by the divertor where the heat load decreased due to the N_2 seeding. These results indicate that three-dimensionally localized structure of radiative cooling was detected experimentally. The toroidally asymmetric behavior with the different impurity seeding is also presented in the talk.

References

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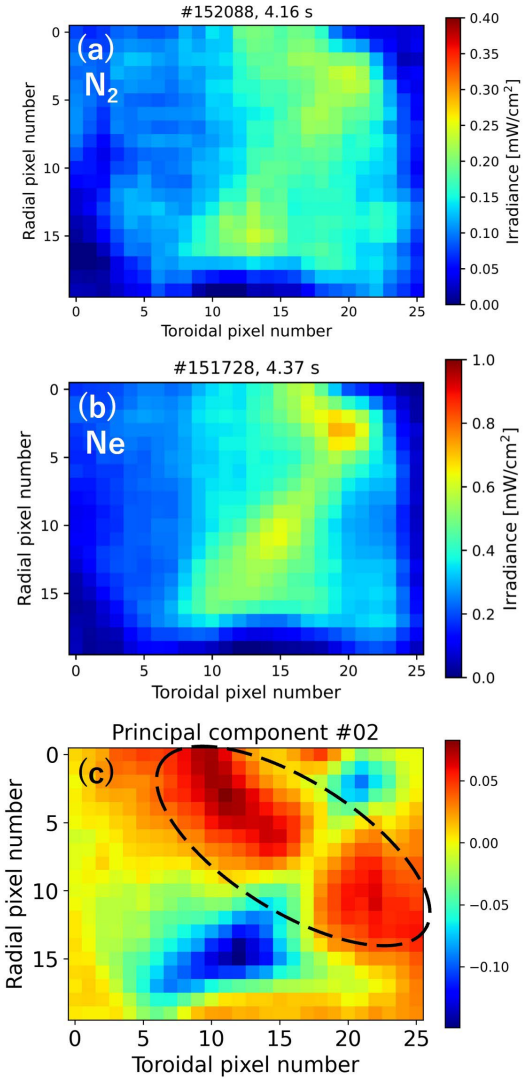

Figure 1 Typical radiation images of IRVB in (a) N_2 and (b) Ne seeded plasmas. (c) Principal component extracted from 68 images of N_2 and Ne seeded plasmas. A dashed ellipse indicates the localized structure in N_2 seeded plasmas.