§13. Analysis of Bolometric Images

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In recent years a new imaging bolometer known as the Infrared Imaging Video Bolometer (IRVB) has been under development at NIFS [1-5] which relies on a large (66 x 90 mm) thin (1mm) gold foil. The IR camera images are cropped to a 120 x 160 pixel image including the foil and a portion of the surrounding copper frame as shown by two consecutive images in Figs. 1(a) and (b). Next the images are resampled to 12 x 16 pixels using a linear interpolation technique as shown in Figs. 1 (c) and (d). This creates one bolometer pixel by effectively averaging over 100 IR camera pixels, reducing the noise by a factor of 10 as can be observed in the images. In order to solve the heat diffusion equation for the foil a numerical algorithm is used. This results in equations for the plasma radiated power density, S_{radp}, (Fig. 1(h)) incident on the foil in terms of the time derivative, S_t(Fig. 1(f)), and Laplacian, S_s(Fig. 1(e)), terms, given by Eqs. 1-3, and the blackbody radiation term, S_{bb}(Fig. 1(g)), which is emitted by the graphite blackened side of the foil facing the IR camera and can be calculated from the Stefan-Boltzmann law where x and y are the horizontal and vertical coordinates on the foil respectively, t is time, t_f is the foil thickness, k is the effective thermal conductivity of the foil, l is the dimension of the square bolometer pixel, κ is the effective thermal diffusivity of the foil and Δt is the frame time of the IR camera. The thermal characteristics of the foil, k and κ are determined by the calibration described in Ref. [2]. Calculating the Laplacian, the edge bolometer pixels which image the frame along the edge of the foil are used and then cropped, reducing the image to 10 x 14 bolometer pixels. For the image shown the time derivative term has the greatest contribution with a lesser contribution from the spatial derivative term and a nearly negligible contribution from the blackbody term.

$$S_{radp}(x,y,t) = S_t(x,y,t) + S_s(x,y,t) + S_{bb}(x,y,t) \quad (1)$$

$$S_t(x,y,t) = t_f k\left[T(x,y,t) - T(x,y,t-\Delta t)\right]/\kappa\Delta t \quad (2)$$

$$S_s(x,y,t) = \frac{t_f k}{l^2}\left[\begin{matrix}4T(x,y) - T(x,y+l) - T(x,y-l) \\ -T(x+l,y) - T(x-l,y)\end{matrix}\right]_{t-\Delta t} \quad (3)$$

References

[1] B.J. Peterson, *Rev. Sci. Inst.***71**(2000)3696.
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[4] N. Ashikawa et al., *JPFR Ser.* **4**(2001)437.
[5] B.J. Peterson et al., *IEEE Trans. Plasma Sci.* **30** (2002) 52.

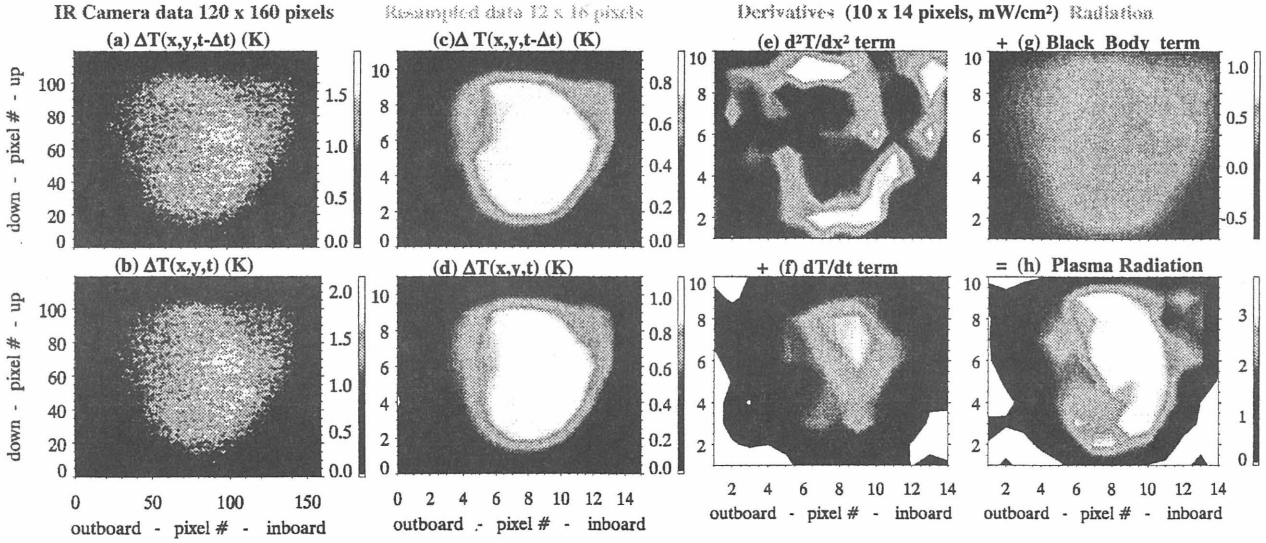

Fig. 1. Sequence of images showing data analysis technique of the IRVB for data taken from LHD during an experiment using the inboard wall as a toroidally periodic limiter. (a) and (b) two consecutive IR camera temperature images. (c) and (d) images (a) and (b) after resampling. Contributions to (h) radiated power density calculation, S_{radp}: (e) spatial derivative term, S_s, (f) time derivative term, S_t, (g) black body radiation term, S_{bb}.