Infrared Phys. Vol. 23, No. 5, pp. 293–294, 1983
Printed in Great Britain.

0020-0891/83 \$3.00 + 0.00

TECHNICAL NOTE

THE EFFECTIVE SIZE OF MERCURY DISCHARGE LAMPS IN THE FAR-INFRARED

D. BINGHAM and C. H. BURTON
CSIRO Division of Applied Physics, Sydney, Australia 2070

(*Received* 13 *June* 1983)

Abstract—We have measured the relative distributions of radiance of two mercury discharge lamps across their length and width as a function of the maximum frequency detected. In the far-infrared region there are contributions to the radiant flux from the lamp envelope and the discharge. The full width at half-maximum (FWHM) of the discharge contribution is 4.0 mm, whilst the envelope contribution FWHM is 10.5 mm.

Far-infrared Fourier transform spectrometers use high pressure mercury discharge lamps as sources. Their radiant output comes from both the discharge ($T \sim 10^4$ K) and from the hot quartz envelope ($T \sim 10^3$ K). The envelope is opaque in the frequency interval 60 THz > ν > 3 THz but for lower frequencies it becomes progressively transparent.[1] Since the lamps are cylindrical, with typical diameters of 12 mm, spectrometers commonly have source apertures of this magnitude. The beam divergence, concomitant with the finite source size, is characterized by the half-angle α. It affects both the maximum resolving power, given by $\nu/\Delta\nu = 1/\alpha^2$ and the wavelength scale.[2] The wavelength scale correction (Jaquinot) factor for a uniform circular source,

$$f = 1 - \alpha^2/4, \tag{1}$$

is of the order of unity, but it can be significant at high resolution, as has been observed by Burton and Akimoto.[3] Errors may result if it is assumed that the source aperture is filled at all frequencies. As the discharge is visibly smaller than the envelope, this assumption is unlikely to be true. To elucidate this point, we have measured the relative distributions of radiance of two mercury discharge lamps across their length and width as a function of the maximum detected frequency ν_{max}.

A simple experimental arrangement was used, consisting of a water cooled vertical slit 10 × 0.8 mm behind which the lamp was traversed. A TPX lens[4] was used to image the slit onto a Golay detector. The use of a black polyethylene film covering the detector window limited the detected frequencies to the range $\nu \leqslant 30$ THz. A section along the length of a lamp (Philips HPK 125 W) was defined by a cooled window, 10 mm long by 7 mm wide. Mounting the lamp horizontally allowed the radiance along the length of the lamp to be measured: as expected this was found to be constant. With the lamp vertical, measurements across the width of both this lamp and a Philips HPL/N 125 W lamp were made. These showed the presence of two distinct contributions to the total radiant flux as shown in Fig. 1.

The central component, due to the discharge, increases in importance as the higher frequencies are cut by the introduction of the low-pass interference filters $\nu_{max} = 2.0$ THz and $\nu_{max} = 0.99$ THz. The full width at half-maximum was found to be 4.0 mm and is the same in both lamps. The Jacquinot correction for this contribution then becomes[3].

$$f = 1 - \theta^2/6 - \phi^2/6,$$

where θ and ϕ are the half-angular width and height. For $\nu_{max} = 2.0$ THz and $\nu_{max} = 0.99$ THz, the broad second component has a shape similar to that measured for $\nu_{max} = 30$ THz, where the envelope is opaque, so it is reasonable to assume that it originates from the quartz envelope. The

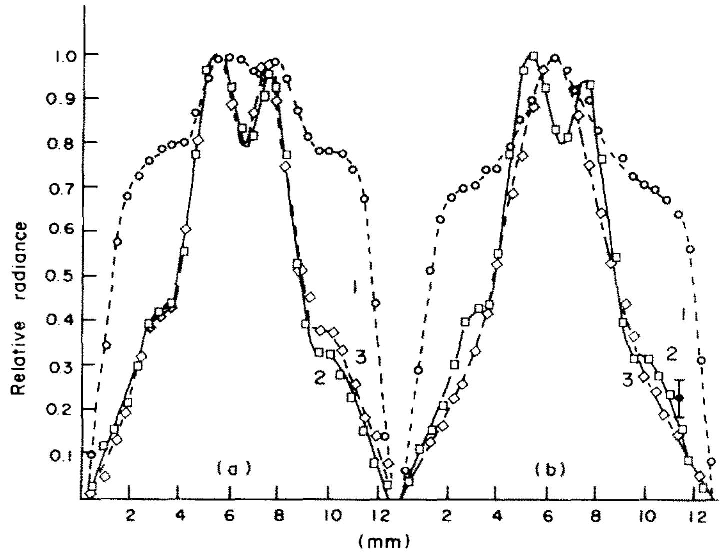

Fig. 1. Relative radiance across the width of the lamp envelopes. (a) A dimpled Philips HPK 125 W. Curves labelled are: (1) $\nu_{max} = 30$ THz; (2) $\nu_{max} = 2.0$ THz; (3) $\nu_{max} = 0.99$ THz. (b) An undimpled Philips HPL/N 125 W. Curves labelled are: (1) $\nu_{max} = 30$ THz; (2) from Fig. 1(a) for comparison; (3) $\nu_{max} = 2.0$ THz. The relative radiance for $\nu_{max} = 0.99$ THz is indicated by the data point at 11.3 mm.

rapid oscillations in the measured radiances of the Philips HPK 125 W lamp can be attributed to the dimpling of the lamp envelope which acts as a series of lenses. This dimpling is performed in order to prevent interference effects within the envelope wall. It is interesting to note that even for frequencies lower then 0.9 THz, the envelope contribution is still approximately 40% of the total. The measurements with the 0.99 THz low-pass filter show a small increase in the relative contribution of the envelope. In the $\nu = 2.0$ to $\nu = 0.99$ THz region, the relative proportion of the discharge and envelope contributions should remain constant, or the former should dominate as the envelope transmittance increases. Our results are not inconsistent with this interpretation although they are suggestive of the discharge becoming optically thin in this frequency region, and has been noted by Cano and Mattiloli[5] in the region of $\nu \sim 0.75$ THz.

REFERENCES

1. Martin A. E., *Infrared Interferometric Spectrometers*, p. 104. Elsevier, Amsterdam (1980).
2. Griffiths P. R., *Chemical Infrared Fourier Transform Spectroscopy*, p. 31. Wiley, New York (1975).
3. Burton C. H. and Akimoto Y. *Infrared Phys.* **20**, 115 (1980).
4. Chantry G. W., Evans H. M., Fleming J. W. and Gebbie H. A., *Infrared Phys.* **9**, 31 (1969).
5. Cano R. and Mattiloli M., *Infrared Phys.* **7**, 25 (1967).