The 1/4 keV X-ray Background: a Reply

An objection[1] has recently been raised to the use of X-ray production by suprathermal proton bremsstrahlung (SPB) to explain the X-ray observations at 1/4 keV[2]: it was pointed out that the soft X-ray flux measured at low galactic latitudes could not be reproduced on the basis of SPB production in the plane when account is taken both of absorption of the X-rays by photoionization in the galaxy and of the cut-off in the proton spectrum due to ionizing collisions in the interstellar gas. The purpose of the original paper[2] was, however, a calculation of the diffuse X-ray background at 1/4 keV which could be expected to be incident on the galaxy from SPB interactions occurring in the intergalactic medium. As such, it made no reference to X-ray production in the galactic plane; further, since the computed X-ray spectra were those incident on the periphery of the galaxy, it is clear that any objection to these results based on a neglect of absorption in the galaxy is not applicable.

De Freitas Pacheco[1] calculated the 1/4 keV X-ray flux expected from SPB interactions of the (demodulated) locally measured proton spectrum with the ambient interstellar electrons in the galactic plane. He concluded that the theoretical flux is several orders of magnitude less than that observed. On the other hand, in ref. 2 it was assumed that the locally determined proton spectrum was extant in either the metagalaxy, the local group or the galactic halo (Cases I, II, and III respectively). The diffuse background X-ray spectrum was then determined from SPB interactions of this proton flux with the distribution of electrons present in each of the relevant volumes. These two approaches are very much dissimilar; to conclude, therefore, that the failure of the former necessarily argues in any respect against the latter is distinctly misleading.

The appropriate conclusion to be drawn is that the SPB process (within the limits of the assumptions noted in ref. 2) remains a viable mechanism for the production of the diffuse isotropic extragalactic background at 1/4 keV, but X-ray production in the galactic plane by SPB certainly cannot account for the soft X-ray enhancement apparently present at low galactic latitudes[3].

Robert L. Brown

National Radio Astronomy Observatory,
PO Box 2,
Green Bank, West Virginia 24944

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Interferometric Method for determining Refractive Index and Thickness of Thin Films

It is often desirable in surface studies to measure the thickness and refractive index of thin films trapped between solid bodies. If these films are transparent I have found that it is possible by multiple beam interferometric methods to determine simultaneously both thickness and refractive index by considering the odd and even orders of interference.

I have analysed the transmitted fringe pattern produced when white light is directed normally on to a symmetrical five layer interferometric sandwich silvered on both sides (Fig. 1). My results show that there are bright fringes in the transmitted beam at those values of $k(k=2\pi/\lambda)$ that satisfy

$$\tan(k\mu_3 T)=\frac{(1-r_1^2)\{\sin 2k(\mu_2 Z+\mu_1 Y)-2r_2\sin(2k\mu_2 Z)+r_2^2\sin 2k(\mu_2 Z-\mu_1 Y)\}}{2r_1\{1-2r_2\cos(2k\mu_1 Y)+r_2^2\}-(1+r_1^2)\{\cos 2k(\mu_2 Z+\mu_1 Y)-2r_2\cos(2k\mu_2 Z)+r_2^2\cos 2k(\mu_2 Z-\mu_1 Y)\}} \tag{1}$$

where $r_1=(\mu_2-\mu_3)/(\mu_2+\mu_3)$ and $r_2=(\mu_1-\mu_2)/(\mu_1+\mu_2)$.

If the two layers 1 are initially in contact ($T=0$, $Z=0$) and are then separated a small distance, equation (1) predicts that the shifts in wavelengths of the odd and even fringes will in general be different, depending on the thicknesses T, Z and the refractive indices μ_3, μ_2 of these sandwiched layers. For small gaps between the surfaces of layers 1 ($2Z+T$ less than 300 Å) one obtains to about 1% accuracy that

$$\left.\begin{aligned} 2Z+T&=n\Delta\lambda/2\mu_1 \text{ for odd order fringes } (n \text{ odd})\\ 2Z\mu_2^2+T\mu_3^2&=n\Delta\lambda\mu_1/2 \text{ for even order fringes } (n \text{ even})\end{aligned}\right\} \tag{2}$$

where $\Delta\lambda$ is the shift in wavelength λ of the nth order fringe (as observed in the spectrometer).

In the special case when $Z=0$ equations 1 and 2 reduce to those which may be derived from an extension of the Hunter and Nabarro treatment[1]. For small gaps equations (2) now become

$$\left.\begin{aligned} T&=n\Delta\lambda/2\mu_1 \text{ for } n \text{ odd}\\ T\mu_3^2&=n\Delta\lambda\mu_1/2 \text{ for } n \text{ even}\end{aligned}\right\} \tag{3}$$

Odd order shifts are independent of μ_3, the refractive index of the gap material, thus giving T directly, whereas even order shifts do depend on μ_3. Equations (3) therefore allow the simultaneous measurement of T and μ_3. When $\mu_3=\mu_1$ the equations for odd and even orders become identical. If accurate measurements are required the $\Delta\lambda$ that appears in equations (2) and (3) should be multiplied by a factor that is close to unity which takes into account the dispersive phase change on reflexion at the silvered interfaces as well as the dispersion in medium 1.

The limits of resolution of multiple beam interference fringes using modern optical techniques make it possible to measure T to about 1 Å and this sets the effective limit to which T and μ_3 may be obtained by the method described. Thus refractive

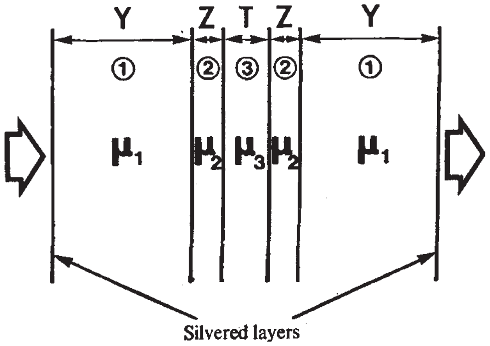

Fig. 1 Interferometer made up of five layers of thickness Y, Z, T, Z, Y, and refractive index μ_1, μ_2, μ_3, μ_2, μ_1, with the two outer surfaces silvered. A beam of white light is incident on the left face; the transmitted beam emerges from the right and may be focused onto a spectrometer slit for analysis.