



FIG. 3. Q versus P graph in  $\text{Sm}_{0.8}\text{Tb}_{0.2}\text{S}$  and in the high pressure phase of SmS.

increase of pressure the Fermi level probes the region of density of states lying below the centre of 4f resonance. This gives rise to  $[d\tau/dE]_{E_F}$  becoming negative with pressure leading to large positive values of Q. It is of interest to study the low temperature behaviour of the high pressure phase of SmS and experiments in this direction are in progress in our laboratory.

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1. Ramesh, T. G. and Shubha, V., *Solid State Comm.*, 1976, 19, 591.
2. Hirst, L. L., *Phys. Kond. Mat.*, 1970, 11, 255.
3. Jayaraman, A., Dernier, P. D. and Longinotti, L. D., *Phys. Rev.*, 1975, 11 B, 2783 (and references therein).
4. Tao, L. J. and Holtzberg, F., *Ibid.*, 1975, 11 B, 3842.
5. Ramesh, T. G. and Shubha, V., *Proceedings of the International Conference on Valence Instabilities and Related Narrow Band Phenomenon Held in Rochester, New York, 1976.*

## HIGH ENERGY SINGLE AND DOUBLE PLASMON SATELLITES IN THE Be AUGER SPECTRUM

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#### ABSTRACT

Relative intensities of high energy single and double plasmon satellites in the Be Auger spectrum have been calculated as 0.0058 and 0.0061 respectively. The calculated values agree fairly well with the corresponding experimental values 0.0053 and 0.0047 of Jenkins *et al.*

SCHMIDT<sup>1</sup>, Steinmann<sup>2</sup> and Neddermeyer and Wiech<sup>3</sup> have shown theoretically that the involvement of plasmon in the emission of high energy satellites is possible. Evidence for the existence of high energy plasmon satellites have been shown by several workers<sup>4-9</sup>. Recently Jenkins *et al.*<sup>5</sup> have observed two high energy satellites at energy distances of 18 eV and 38 eV from the main Be (KVV) Auger peak on the high energy side. They have assigned the first satellite ( $\text{KVV} + \hbar\omega_p$ ) as due to single plasmon energy gain by the Auger electron, while the second satellite at 38 eV has been assigned  $[(\text{K})_2 \text{VV}]$  as due to double ionization. The last assignment is based on the rough approximation which Jenkins and Zehner<sup>5</sup> have made for the ionization energy of the

second K-electron of Be. Recent calculations by Hayasi<sup>10</sup>, assuming double ionization, place the main band-high energy satellite separation at 34.07 eV for Be. This value does not agree with the experimental value of either Jenkins *et al.*<sup>5</sup> (38 eV) or of Hayasi<sup>11</sup> (37.6 eV). In fact the experimental values of both the workers are in excellent agreement with the double plasmon energy ( $2\hbar\omega_p = 38$  eV). Thus on the basis of energy consideration the high energy satellite at 38 eV can be assigned as due to double plasmon energy gain, rather than the double ionization process.

Jenkins and Zehner<sup>5</sup> have also observed two low energy satellites at 18 eV and 38 eV to which they claim respectively as due to single and double

plasmon creation by the Auger electrons. That is, the existence of plasmons up to several orders in Be is possible<sup>12</sup>. It is also possible that on decay, plasmons can give their energy to Auger electrons giving rise to high energy plasmon satellites up to several orders. Thus the satellites at 18 eV and 38 eV on the high energy side of main Auger peaks may be respectively due to single and double plasmon energy gain process. The first satellite at 18 eV has already been assigned by Jenkins and Zehner<sup>5</sup> as due to single plasmon energy gain process. The second satellite at 38 eV, on the basis of energy consideration can be assumed as due to plasmon energy gain process.

A further check to the double plasmon energy gain process is the calculation of the relative intensity of this satellite with respect to the main peak. Following Langreth<sup>13-14</sup>, the relative intensity of the double plasmon satellite can be given as :

$$i = \frac{0.06 \gamma^2}{2 e^{-\gamma}} \quad (1)$$

where

$$\gamma = \frac{\gamma_s}{6} \quad (2)$$

$\gamma_s$  is a dimensionless parameter and is given<sup>15</sup> by :

$$\gamma_s = \left( \frac{47.11}{\hbar \omega_p} \right)^{2/3} \approx 1.9 \quad (3)$$

From equation (1) the calculated value for  $i$  is 0.0061 which is in close agreement with the experimental value 0.0047 of Jenkins<sup>16</sup> (see Table I).

The calculated value of  $i$  from equation (4) is 0.0058 which is in fair agreement with the experimental value (0.0053) of Jenkins<sup>16</sup> (see Table I).

The relative intensities of both satellites, i.e., at energy distances of  $\hbar \omega_p$  and  $2\hbar \omega_p$  (0.0058 and 0.0061) which are approximately of the same order of magnitude, satisfy the general characteristic of the plasmon involvement. This again strengthens our argument. Thus we can safely say that both the satellites on the high energy side of the main Auger peak of Be spectrum are due to plasmon energy gain process and they can be given respectively the following assignment ( $KVV + \hbar \omega_p$ ) and ( $KVV + 2\hbar \omega_p$ ).

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1. Schmidt, V. V., *Soviet Phys. JETP.*, 1961, 12, 886.
2. Stainmann, W., *Phys. Stat. Sol.*, 1968, 28, 437.
3. Neddermeyer, H. and Wiech, G., *Phys. Lett.*, 1970, 30 A, 17.
4. Hanson, W. F. and Arakawa, E. T., *Z. Phys.*, 1972, 251, 271.
5. Jenkins, L. H. and Zehner, D. M., *Solid State Commun.*, 1973, 12, 1149.
6. Arakawa, E. T. and William, M. W., *Phys. Rev.*, 1975, 8 B, 4075.
7. Srivastava, K. S., Singh, S. P. and Shrivastava, R. L., *Phys. Stat. Sol.* (in press).

TABLE I  
Relative intensity of single and double plasmon satellite in Be Auger spectrum

Metal	$\alpha$	$\beta$	$\hbar \omega_p$ (eV)	$\gamma_s$	Relative intensity (i)			
					Authors' value		Experimental value <sup>16</sup>	
					Single plasmon	Double plasmon	Single plasmon	Double plasmon
Be	0.3577	0.71	18.0	1.9	0.0058	0.0061	0.0053	0.0047

Thus the satellite at 38 eV on the high energy side of the main Auger peak KVV may be due to double plasmon energy gain process rather than double ionization process and thus can safely be given the following assignment ( $KVV + 2\hbar \omega_p$ ).

The relative intensity of the first plasmon satellite at 18 eV ( $\hbar \omega_p$ ) can also be calculated using Srivastava *et. al.*<sup>7-9</sup> and Brouers<sup>17</sup> formula :

$$i = a \left[ 1 - \frac{3}{2} \sqrt{\frac{2}{\beta}} \tan^{-1} \sqrt{\frac{\beta}{2}} + \frac{1}{2} \frac{1}{(1 + \beta/2)} \right] \quad (4)$$

where  $a = 0.3577$ ,  $\beta = 0.71$  (See reference 15).

8. —, — and —, *Phys. Lett.*, 1974, 47 A, 305.
9. —, Shrivastava, R. L. and Singh, S. P., *Phys. Stat. Sol.* (in press).
10. Hayasi, Y., *Sci. Rep. Tohoku Univ.*, 1969, 52 (1), 41.
11. —, *Ibid.*, 1968, 51 (1) 1.
12. Jenkins, L. H., Zehner, D. M. and Chung, M. F., *Surface Sci.*, 1973, 38 A, 327.
13. Langreth, D. C., "Collective properties of Physical system," *Nobel*, 1973, 24, 210.
14. —, *Phys. Rev. Lett.*, 1971, 26, 1229.
15. Rook, G. A., *Soft X-ray Band Spectra*, Edited by D. J. Fabien, Academic Press, 1968, p. 5.
16. Jenkins, L. H., Private Communication.
17. Brouers, F., *Phys. Lett.*, 1964, 11, 297.