

Finally, it is concluded that throughout the investigated energy region, the experimental results are deviating positively from the direct theory and this positive deviation is found to be increasing with increasing energy. But the detour theory is found to be successful in explaining the experimental excess over the theory only in the middle energy region. It is therefore desirable to develop new theories by taking into account new effects if there are any, which were ignored in the existing theories and which are likely to augment the IB intensities especially at high photon energies.

1. Persson, B., *Pre. Conf. on the Electron Capture and Higher Order Processes in Nuclear Decays*, Debrecen, 1968.
2. Knipp, J. K. and Uhlenbeck, G. E., *Physica*, 1936, 3, 425.
3. Bloch, F., *Phy. Rev.*, 1936, 50, 272.
4. Chang, C. S. W. and Falkoff, D. L., *Ibid.*, 1949, 56, 365.
5. Madansky, L., Lipps, F., Bolgiano, P. and Berlin, T. H., *Ibid.*, 1951, 84, 596.
6. Nilsson, S. B., *Ark. Fys.*, 1956, 10, 467.
7. Lewis, R. R. and Ford, G., *Phy. Rev.*, 1957, 107, 756.
8. Vinh-Mau, R., *Nuovo Cimento*, 1961, 19, 609.
9. Spruch, L. and Gold, W., *Phy. Rev.*, 1959, 113, 1060.
10. Felsner, G., *Z. PHY.*, 1963, 174, 43.
11. Longmire, C., *Phy. Rev.*, 1949, 75, 15.
12. Horowitz, J., *J. PHY. et Radium*, 1952, 13, 429.
13. Hakeem, M. A. and Goodrich, M., *Nucl. Phy.*, 1962, 31, 322.
14. Ford, G. W. and Martin, C. F., *Ibid.*, 1969, 134 A, 457.
15. Beattie, R. J. D. and Byrne, J., *Ibid.*, 1971, 161 A, 650.
16. Powar, M. S. and Singh, M., *J. Phy.*, 1972, 5, 460.
17. Persson, B., *Nucl. Phy.*, 1964, 55, 49.
18. —, *Ibid.*, 1965, 67, 121.
19. Bolgiano, P., Madansky, L. and Rasetti, F., *Phy. Rev.*, 1953, 89, 679.
20. Narasimha Murty, K. and Jnanananda, S., *Proc. Phy. Soc.*, 1967, p. 109.

EXPLOSIVE PHASE TRANSFORMATION IN $Sm_{0.8} Tb_{0.2} S$

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WE recently reported the thermo-power study of the isostructural electronic phase transition in SmS which occurs around 6.5 Kbar pressure¹. The semiconductor to metal transition manifests itself as a dramatic drop in thermo-power (Q) followed by a change of sign. After the phase transition, Q increases anomalously over a narrow pressure range. It is well known that the high pressure phase of SmS is in a mixed valance or inter-configurational fluctuation state² (ICF). Further the effect of pressure can be simulated by substituting smaller trivalent ions like Tb³⁺, Gd³⁺, Y³⁺, etc., for the larger divalent Sm ions in the SmS lattice^{3,4}. Thus the critically doped and 'Chemically collapsed' systems like $Sm_{0.8} Tb_{0.2} S$, $Sm_{0.84} Gd_{0.16} S$, etc., exhibit properties which are similar to the high pressure phase (metallic phase) of SmS.

In this communication we report some new data on the thermoelectric behaviour of the chemically collapsed $Sm_{0.8} Tb_{0.2} S$ system in the temperature range $-200^{\circ} C$ to $+200^{\circ} C$. Further this study gives evidence that the black phase obtained after the explosive phase transformation^{3,5} at $-170^{\circ} C$ (B'-Phase) is quite distinct from the normal black phase (B-phase).

Figure 1 gives the temperature-concentration diagram³ of a typically doped material like $Sm_{1-x} Gd_x S$. For concentrations less than the critical value the material will be in the B-Phase (FCC) which is the normal semiconducting phase. For concentrations greater than a critical value and for temperatures above $100^{\circ} K$, the black phase undergoes an isostructural first order phase transformation to a metallic phase (M). This metallic phase on cooling undergoes an explosive phase transformation to the B'-phase, near liquid nitrogen temperature. There is evidence to indicate that this is also an isostructural transformation³. As mentioned earlier this study clearly shows that B and B' are electronically distinct phases.

Figure 2 presents the variation of Q with temperature ranging from $-200^{\circ} C$ to $+200^{\circ} C$ for $Sm_{0.8} Tb_{0.2} S$. The most notable feature is the change of sign of Q at lower temperatures followed by very large increase in its magnitude ($Q \approx -40 \mu V/^{\circ} C$ at $-150^{\circ} C$). The explosive phase transformation from the metallic to the B'-phase is seen by the large discontinuity in Q occurring near $-170^{\circ} C$. The sign of Q is positive in the B'-phase. From our earlier studies¹, we note that Q is negative in the B-phase

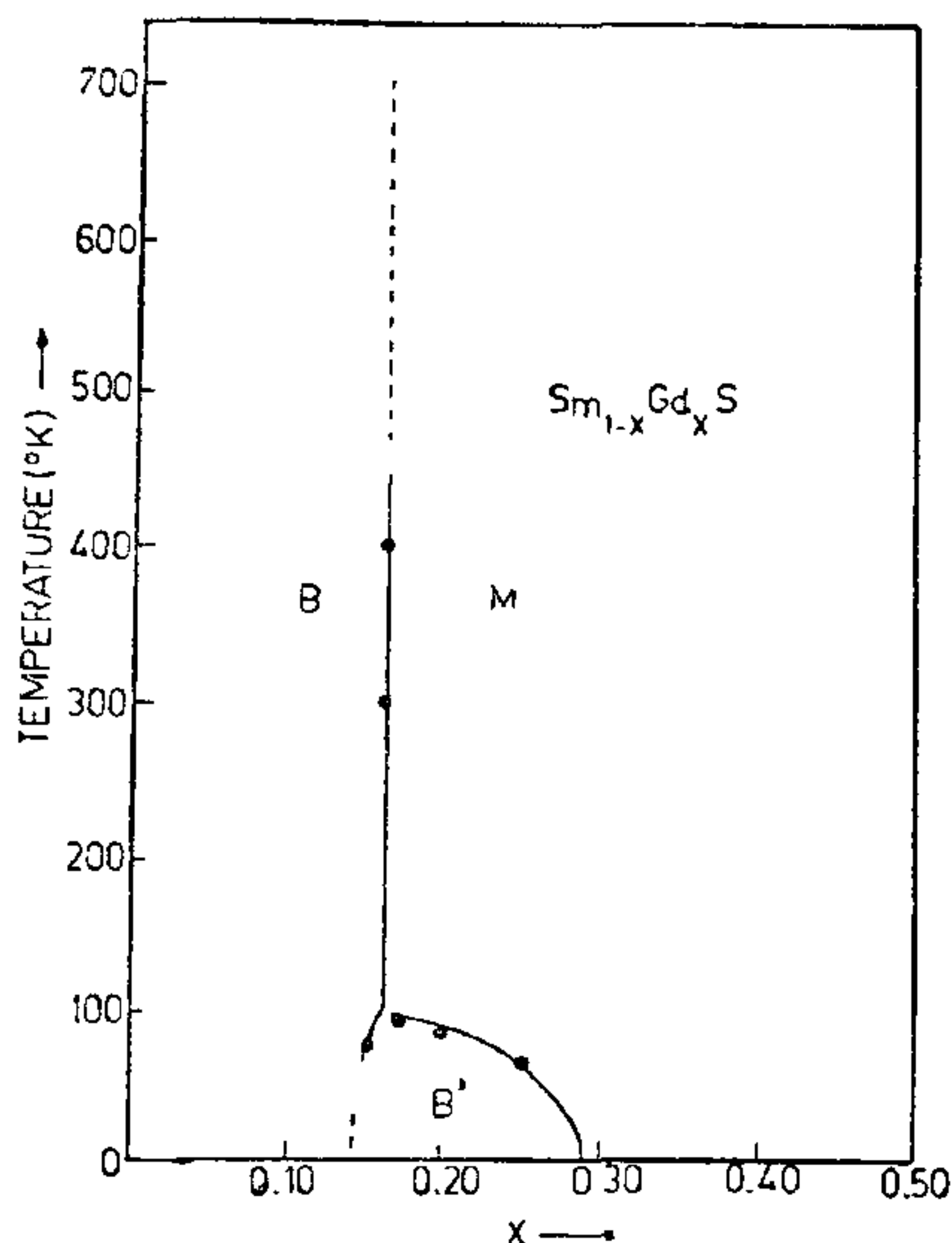


FIG. 1. Phase diagram of $\text{Sm}_{1-x}\text{Gd}_x\text{S}$ system. B—Normal semiconducting phase; M—Metallic phase; B'—New black phase after the explosive phase transformation.

which suggests that the electronic structures of the B and B' phases are different. The decrease of Q at higher temperatures leading to a change of sign around $+200^\circ\text{C}$ is associated with the continuous phase transformation from the metallic to the B-phase.

Figure 3 gives the pressure dependence of Q in $\text{Sm}_{0.8}\text{Tb}_{0.2}\text{S}$ and in the metallic phase of SmS . It may be noted that over a narrow pressure range, the thermo-power increases anomalously in both these systems and their remarkably identical behaviour is indicative of the close similarity in their electronic structure.

The anomalous temperature and pressure dependence of Q in these $4f$ substances can be qualitatively understood on the basis of the Hirst Model² according to which the $4f$ band with a high density of states lies at the Fermi level. The central result of Hirst's model is that the Samarium ions in the high pressure phase of SmS or in the chemically collapsed $\text{Sm}_{0.8}\text{Tb}_{0.2}\text{S}$ are rapidly undergoing inter-configurational fluctuations between the isoenergetic $4f^65d^0$ and $4f^55d^1$ states. For temperatures $kT \ll \Delta$, where Δ represents the width of the $4f$ resonance, the ions would be in a well defined configuration and when $kT \gg \Delta$, the ionic configuration will be rapidly varying leading to the

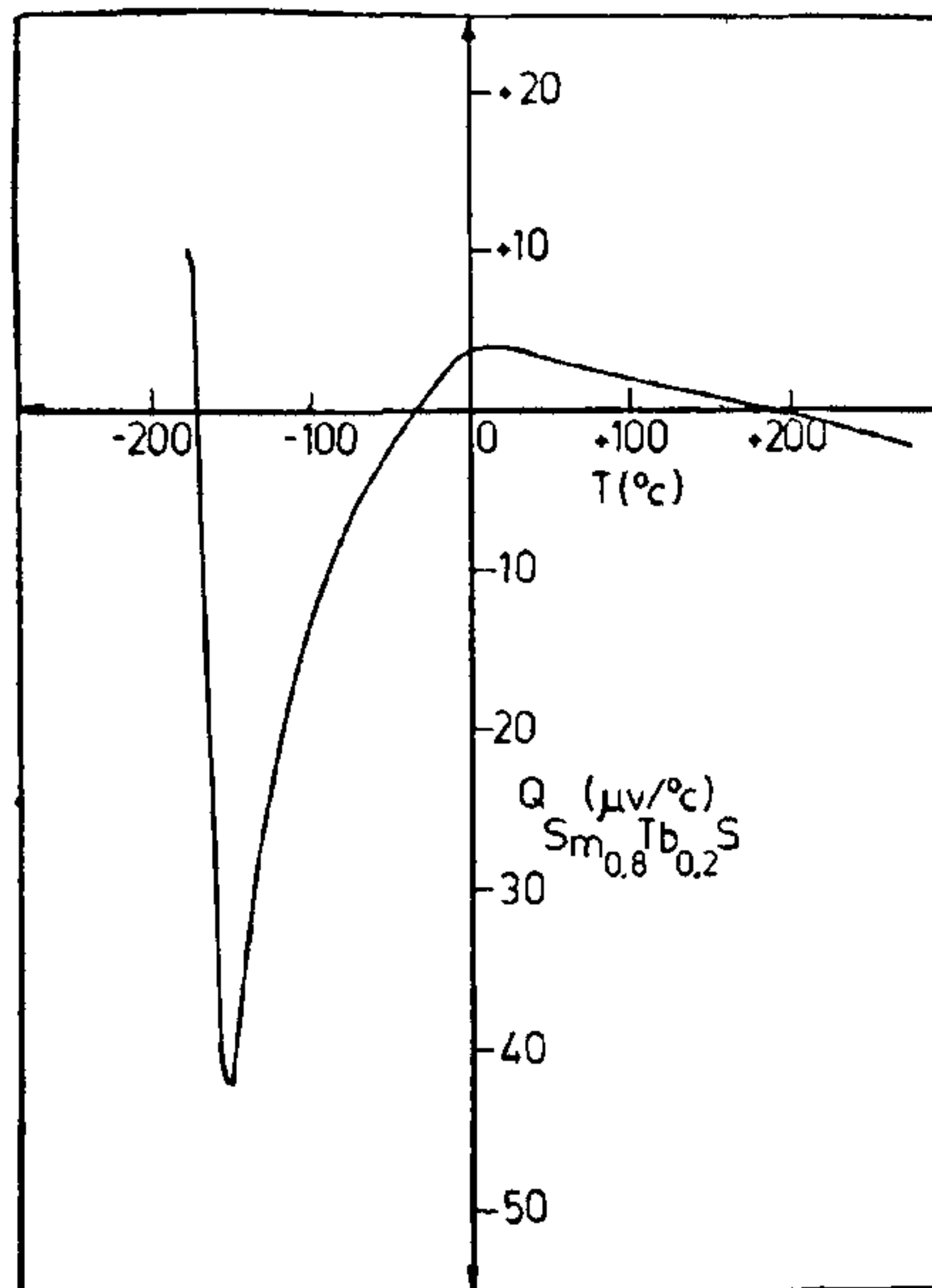


FIG. 2. Explosive phase transition in $\text{Sm}_{0.8}\text{Tb}_{0.2}\text{S}$. The discontinuity in Q near -170°C corresponds to the M-B' phase transformation.

phenomenon of 'mixed valence'. Also the application of pressure will move the Fermi level away from the centre of $4f$ resonance which again will lead to a continuous change in the fractional valence. The amount of fractional valence can thus be varied continuously by the application of pressure or temperature.

It is well known that the thermo-power of a metal depends on the energy derivative of the relaxation time (τ) and the density of states at the Fermi level. The anomalous increase of thermo-power with decrease of temperature (Fig. 2) suggests that $[d\tau/dE]_{E_F}$ is positive, (which makes a negative contribution to thermopower) and its magnitude increases with decrease of temperature. Since the concentration of electrons possessing $5d$ character, which effectively carry the current decreases with decrease of temperature the magnitude of Q would become large at lower temperatures. The decrease in Q at higher temperatures (0°C to 200°C) can be correlated with the continuous change of valence of Samarium ions towards the divalent state.

The anomalous pressure behaviour (Fig. 3) can be explained if one assumes that with the

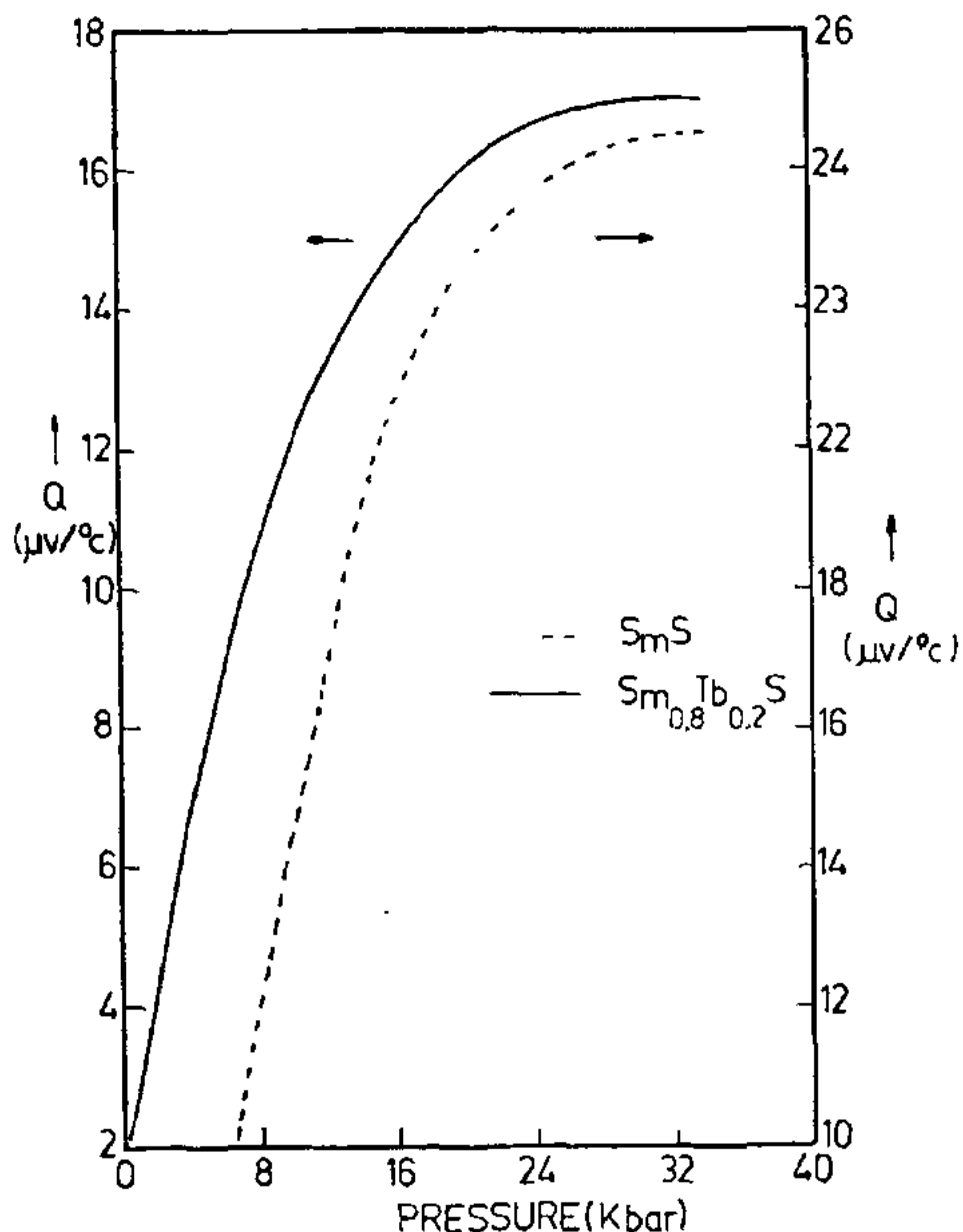


FIG. 3. Q versus P graph in Sm_{0.8}Tb_{0.2}S and in the high pressure phase of SmS.

increase of pressure the Fermi level probes the region of density of states lying below the centre of 4f resonance. This gives rise to $[d\tau/dE]_{F}$ 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.*

SCHMIDT¹, Steinmann² and Neddermeyer and Wiech³ 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 workers⁴⁻⁹. Recently Jenkins *et al.*⁵ 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 (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 [(K)₂ VV] as due to double ionization. The last assignment is based on the rough approximation which Jenkins and Zehner⁵ have made for the ionization energy of the

second K-electron of Be. Recent calculations by Hayasi¹⁰, 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.*⁵ (38 eV) or of Hayasi¹¹ (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 Zehner⁵ have also observed two low energy satellites at 18 eV and 38 eV to which they claim respectively as due to single and double