

of  $F_{obs}^4$  or  $F_{obs}^5$  could be found at the same abscissas as  $F_{obs}^4$  or  $F_{obs}^5$ . If the corresponding pairs of values are multiplied by proper coefficients and then be added or subtracted, a series of values of  $F_{obs}^+$  and  $F_{obs}^-$  could be obtained which are now pure functions of  $F_a$  and  $F_b$ . Then if  $\ln(F_a/F_{obs}^+)$  and  $\ln(F_b/F_{obs}^-)$  are plotted against  $\sin^2\theta/\lambda^2$  respectively, two straight lines could be obtained which should intercept at the same point on the ordinate axis, the slopes of which represent respectively  $B_a$  and  $B_b$ .

In the Debye theory of specific heats, the Debye parameter  $B$  may be expressed as  $(6^{\frac{1}{2}} T / (M \Theta_D^3)) \{ \phi(x) + \frac{1}{2} \}$ , where  $h$  and  $k$  represent Plank constant and Boltzmann constant respectively,  $M$  is the mass of the atom, and  $T$  is the absolute temperature at the time of taking Debye-Scherrer photographs.  $\Theta_D$  is the Debye characteristic temperature,  $x = \Theta_D/T$ , and  $\phi(x)$  is a function of  $x$ , given in original Debye theory. If we let  $G = 6^{\frac{1}{2}} T / (M \Theta_D^3)$ , then  $\phi(x) + \frac{1}{2} = Gx^2$ . Solution of this equation may be performed graphically. Thus by making  $y = Gx^2$  and  $y_2 = \phi(x) + \frac{1}{2}$ , the plotting of these two equations should give two curves, the intersection of which should give the value of  $x$  determining the characteristic temperature at that temperature.

By means of these methods, the characteristic temperature of Al, Au and Pb have been determined to be 376K, 205K and 90K respectively. In the case of Zn, the characteristic temperature parallel to the principal axis is 212K, which that perpendicular to it is 328K the difference being 116K. For  $CaF_2$  crystals, the characteristic temperature of  $Ca^{2+}$  ion is 400K, while that of  $F^-$  ion is 476K, the difference being 76K.

**11.4-02 DEBYE-WALLER FACTORS OF ZINC BLENDE STRUCTURE COMPOUNDS.** By John S. Reid, Department of Natural Philosophy, University of Aberdeen, Aberdeen, Scotland.

Tables are presented of the Debye-Waller factors for a substantial number of zinc blende structure materials over the temperature range 1K to 1000K (where appropriate). The factors are calculated using eigendata from up to  $3 \times 10^5$  phonon modes obtained from the established lattice dynamical models including the shell model, the valence shell model and the deformation dipole model. Taking good account of the zero-phonon contribution the sampling error is reduced to negligible proportions. These figures provide the best harmonic Debye-Waller factors against which experimental results may be assessed for consistency, quasi-harmonic and other anharmonic contributions, and possible dynamic deformation effects. For most of the materials a comparison is made of the Debye-Waller factors from more than one lattice dynamical model in order to assess whether the Debye-Waller factor is a useful observable to distinguish between lattice dynamical models which fit the symmetry direction frequencies comparably well. Further, values are given for the Debye-Waller factors of the shells in the shell models in order to highlight that some of the electron distribution is modelled to vibrate with substantially different mean square displacements compared with the core. Since this feature of the shell models cannot be uniquely determined from phonon frequency measurements, a discussion is given of the possible role of Debye-Waller factors determined by X-rays in providing lattice dynamical information of real value.

**11.4-03 LOWEST ORDER ANHARMONIC THERMAL SCATTERING OF X-RAYS BY SILICON-LIKE CRYSTALS.** By J.D. Pirie, Department of Natural Philosophy, University of Aberdeen, Aberdeen AB9 2UE, Scotland.

The lowest order anharmonic contribution to thermally scattered X-rays has been calculated for diamond, silicon, germanium and  $\alpha$ -tin. This term can be regarded as an interference between the harmonic one phonon and two phonon scattering processes. The calculations were based on an anharmonic interaction restricted to nearest neighbours and used lattice eigenfrequency-eigenvector data obtained from published parameters for lattice dynamics models. Most of these models had been fitted to measured phonon frequencies.

Results will be presented for the main symmetry directions and other representative points in reciprocal space. This anharmonic contribution to the thermal scattering may be positive or negative and its magnitude will be compared with the harmonic thermal scattering and Compton scattering over a range of temperatures.

**11.4-04 STUDY OF ACOUSTOELECTRIC PHONONS BY ANOMALOUS TRANSMISSION OF X-RAYS.** By L. D. Chapman, R. Colella and R. Bray, Physics Department, Purdue University, W. Lafayette, IN 47907.

Intense beams of non-equilibrium acoustic phonons can be generated in piezoelectric crystals by application of an electric field. In our experiments with InSb the electric field was applied parallel to the [110] direction, along which acoustoelectric (A.E.) amplification takes place. Strong beams of [110] FT phonons are generated, and the resulting attenuation of anomalous transmission (A.T.) along planes parallel and perpendicular to [110] was investigated in detail. Since the phonon beams are localized in travelling domains, a time resolved technique for recording diffraction patterns was used. Up to 14 diffraction patterns with 0.5 usec resolution time were recorded simultaneously for each rocking curve, which was sufficient to observe the whole time evolution of the acoustic flux generated by each phonon domain. The sensitivity of anomalous transmission to small enhancements of atomic vibrations, in conjunction with the time resolved technique, has enabled us to gain valuable information on phonon lifetimes, frequency downshifts, and mode conversions. It has been possible, for example, to ascertain the existence of weak modes that are not A.E. amplified, namely: [110] L and [110] ST. These are due partly to mode conversion at the walls of the crystal, but also, to an appreciable extent, to a mechanism of mode conversion inherently present in the travelling acoustic domain, the nature of which mechanism is at present unknown. This mechanism is such that the [110] L and [110] ST phonons are continuously produced as by-products of the intense [110] FT flux, probably via anharmonic interactions. Since these phonons are not able to survive and to undergo A.E. amplification, they appear to propagate with the speed of the [110] FT phonons.