

TABLE I. Combinations of elastic constants governing pure mode propagation in cubic crystals.

Propagation direction	Particle motion	Type	Elastic constants
[100]	[100]	Longitudinal	C_{11}
[110]	[110]	Shear	$(C_{11} - C_{12})/2$
[100]	\perp to [100]	Shear	C_{44}
[110]	[110]	Longitudinal	$(C_{11} + C_{12} + 2C_{44})/2$
[110]	[001]	Shear	C_{44}
[111]	[111]	Longitudinal	$(C_{11} + 2C_{12} + 4C_{44})/3$
[111]	\perp to [111]	Shear	$(C_{11} - C_{12} + C_{44})/3$

and Ruoff⁸ assumed a linear variation of Δ vs P as described below. We note that

$$\rho = \rho_0 \lambda^3. \quad (14)$$

Beginning with Eq. (9) and substituting for B^S and ρ from (12) and (14), we obtain

$$\Delta(P) = \frac{T\beta^2 \{ [L_1^2(P=0)/\tau_1^2(P)] - \frac{4}{3} [L_2^2(P=0)/\tau_2^2(P)] \}}{\lambda^2 C_P}. \quad (15)$$

Next express $\Delta(P)$ as a power-series expression.

$$\Delta(P) = \Delta_0 + \Delta_0' P + \Delta_0'' (P^2/2) + \dots \quad (16)$$

The logarithmic derivative of Δ as given by (15) yields

$$\Delta^{-1} \left(\frac{\partial \Delta}{\partial P} \right)_T = \frac{2}{\beta} \left(\frac{\partial \beta}{\partial P} \right)_T - \frac{2}{\lambda} \left(\frac{\partial \lambda}{\partial P} \right)_T - \left(\frac{L_1^2(P=0)}{\tau_1^2(P)} - \frac{4}{3} \frac{L_2^2(P=0)}{\tau_2^2(P)} \right)^{-1} \frac{\partial}{\partial P} \times \left(\frac{L_1^2(P=0)}{\tau_1^2(P)} - \frac{4}{3} \frac{L_2^2(P=0)}{\tau_2^2(P)} \right)_T - C_P^{-1} \left(\frac{\partial C_P}{\partial P} \right)_T. \quad (17)$$

We now proceed to evaluate $(\partial \Delta / \partial P)_T$ as $P \rightarrow 0$, i.e., Δ_0' . From Eq. (6) we have

$$\lim_{P \rightarrow 0} - (2/\lambda) (\partial \lambda / \partial P)_T = -2/3 B_0 T. \quad (18)$$

TABLE II. Internal consistency of the adiabatic elastic constant values (in units of 10^{11} dyn/cm²) of RbCl, RbBr, and RbI as a function of temperature ($^{\circ}$ K) at 1 atm.

Temperature	C_{11}		C_{12}		C_{44}	
	(1) ^a	(2) ^b	(1) ^a	(2) ^b	(1) ^a	(2) ^b
III RbI						
300	2.5570	2.5561	0.3766	0.3815	0.2772	0.2777
260	2.6496	2.6519	0.3675	0.3641	0.2792	0.2799
220	2.7490	2.7474	0.3514	0.3506	0.2818	0.2810
180	2.8504	2.8502	0.3354	0.3352	0.2840	0.2844
I RbCl						
300	3.6213	3.6242	0.6154	0.6124	0.4668	0.4678
260	3.7486	3.7519	0.6070	0.6034	0.4713	0.4714
220	3.8756	3.8831	0.5934	0.5899	0.4754	0.4754
180	4.0011	4.0071	0.5753	0.5745	0.4789	0.4794
II RbBr						
300	3.1513	3.1522	0.4995	0.5000	0.3798	0.3801
260	3.2570	3.2624	0.4825	0.4860	0.3831	0.3834
220	3.3691	3.3727	0.4714	0.4731	0.3863	0.3866
180	3.4882	3.4882	0.4587	0.4593	0.3898	0.3900

^a From the experimental runs at higher pressures as a function of temperature.

^b From the experimental runs at one atmosphere as a function of temperature.

TABLE III. Adiabatic elastic constants (in units of 10^{11} dyn/cm²) and density (in units of g/cm³) of RbCl as a function of temperature (°K) as obtained in present work (PW) and those obtained by Marshall, Pederson, and Dorris (MPD).

Temp.	C_{11}		C_{12}		C_{44}		Bulk modulus		Density		Δ
	PW	MPD	PW	MPD	PW	MPD	PW	MPD	PW	MPD	
300	3.6242	3.653	0.6124	0.645	0.4678	0.478	1.616	1.647	2.7969	2.7972	0.0533
280	3.6894		0.6053		0.4695		1.633		2.8033		0.0502
260	3.7519		0.6034		0.4714		1.653		2.8097		0.0471
240	3.8189	3.840	0.5959	0.666	0.4735	0.482	1.670	1.724	2.8160	2.8163	0.0437
220	3.8831		0.5899		0.4754		1.688		2.8223		0.0403
200	3.9448		0.5812		0.4775		1.702		2.8285		0.0367
180	4.0071	4.025	0.5745	0.676	0.4794	0.486	1.719	1.792	2.8346	2.8345	0.0331
160	4.0681		0.5630		0.4813		1.731		2.8404		0.0293
140	4.1194		0.5569		0.4831		1.744		2.8458		0.0254
120	4.1792	4.206	0.5516	0.676	0.4848	0.490	1.761	1.852	2.8504	2.8507	0.0214
100	4.2394	4.266	0.5484	0.676	0.4858	0.491	1.779	1.873	2.8538		0.0172

We also have the following thermodynamic relation:

$$(\partial\beta/\partial P)_T = -[(\partial/\partial T)(1/B^T)]_P. \quad (19)$$

This is true at all pressures, but in the limit we have

$$\lim_{P \rightarrow 0} (\partial\beta/\partial P)_T = (1/B_0^T) (\partial B^T/\partial T)_{P=0}. \quad (20)$$

Likewise

$$\begin{aligned} (\partial C_P/\partial P)_T &= -T[(\partial^2/\partial T^2)(1/\rho)]_P \\ &= -(T/\rho)[(\partial\beta/\partial T)_P + \beta^2]. \end{aligned} \quad (21)$$

Again at the limit we have

$$\lim_{P \rightarrow 0} (\partial C_P/\partial P)_T = -(T/\rho_0)[(\partial\beta/\partial T)_{P=0} + \beta_0^2]. \quad (22)$$

Therefore *all* the terms on the right-hand side of Eq. (17) are known in the limit as $P \rightarrow 0$ if we have sufficient thermal expansion and specific-heat data as a function of temperature at zero pressure to combine with the direct experimental values which we measure and which give the second and third terms. Thus we can evaluate Δ_0' . Hence we have

$$\Delta(P) = \Delta_0 + \Delta_0' P$$

TABLE IV. Temperature derivatives of the adiabatic elastic constants (in units of 10^7 dyn/cm² °K) of RbCl at room temperature.

	Temperature (°K)	C_{11}	C_{12}	C_{44}	Bulk modulus
Present work	300	-30.80	3.40	-0.934	-8.00
Haussuhl	295	-32.12	3.46	-1.094	-8.40
Marshall <i>et al.</i>	300	-31.10	-3.50	-0.667	-12.7

which is then substituted into Eq. (13). Thus we can evaluate λ from (13) and then we get all the pertinent elastic constants. (Note that one does *not* have to have approximate values of $(\partial B_0^S/\partial P)_T$ to carry out this analysis.) Combinations of elastic constants for pure-mode propagation in cubic crystals are given in Table I. In the following sections the elastic constants of RbCl, RbBr, and RbI as a function first of temperature at one atmosphere and then of pressure at several temperatures are discussed. The values presented are (i) based on the travel times evaluated at the resonant frequency of quartz at a pressure P and temperature T . (ii) They are the least-square estimates obtained from four $\rho(P)v(P)$ values, and (iii) they are internally self-consistent. As an example of self-consistency we present the values of the elastic constants of RbCl, RbBr, and RbI as a function of temperature at one atmosphere in Table II. The two values of each constant at a temperature are obtained from two independent experimental runs as indicated underneath Table II. The agreement between these pairs of values are within the range of experimental errors. These errors are estimated to be 0.2%, 0.6%, and 0.4% for C_{11} , C_{12} , and C_{44} , respectively, for each of the rubidium halides. The errors associated with these values of the elastic constants incorporate not only the usual errors of measurements like length of the specimens, absolute null frequency and its reproducibility, and misorientation, but also the statistical or random errors due to replication. The associated errors are thus larger in magnitude than the precision with which each experimental run could be executed. Where some pertinent ancillary data were not available, specific assumptions had to be made. These assumptions are explicitly described in the separate sections dealing with the halides to which they specifically

TABLE V. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbCl as a function of pressure (in units of kilobars) at 304°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	3.609	3.524	0.620	0.537	0.466	1.618	1.533	0.0557	1.00000
0.295	3.644	3.560	0.625	0.542	0.465	1.633	1.548	0.0549	1.00064
0.575	3.683	3.599	0.629	0.545	0.463	1.648	1.563	0.0541	1.00124
0.975	3.741	3.657	0.633	0.546	0.461	1.670	1.586	0.0529	1.00209
1.500	3.817	3.733	0.643	0.559	0.457	1.700	1.617	0.0515	1.00318
2.030	3.887	3.805	0.655	0.566	0.454	1.728	1.646	0.0500	1.00427
2.490	3.953	3.871	0.661	0.574	0.451	1.755	1.673	0.0486	1.00520
2.995	4.018	3.938	0.646	0.581	0.448	1.781	1.700	0.0472	1.00620
3.525	4.088	4.009	0.680	0.592	0.445	1.810	1.731	0.0457	1.00723

pertain. Lastly, we present calculations of the Cauchy and anisotropy relations based on the values of the elastic constants of the three rubidium halides.

RUBIDIUM CHLORIDE

The temperature dependence of the elastic constants of rubidium chloride at one atmosphere has been investigated by Marshall *et al.*⁹ from 4.2° to 300°K, and by Haussühl¹⁰ at high temperatures. We report the variation in the elastic constants as a function of temperature as obtained in the present work and in Ref. 9 (see Table III).

In the calculation of the elastic constants of rubidium chloride a density value of 2.7969 g/cm³ at 300°K is used. The linear thermal expansion coefficient at 293°K is given as $\alpha = 38.13 \times 10^{-6} (\text{°K})^{-1}$ with no temperature variation over the range of 20 to 193°C.¹¹ The values of $\beta(T)$ at lower temperatures are estimated by using the Grüneisen relationship in conjunction with the experimentally determined values of the specific heat at low temperatures.¹² The values of density are included in Table III to show that the use of the specific-heat curve modeled after that of the other alkali halides¹³ by Marshall *et al.*⁹ and the use of the experimental values of the specific heat by us to com-

pute the temperature dependence of the thermal expansion at low temperatures yield very nearly the same values for density at each temperature. Hence, any difference in the temperature dependence of the elastic constants as obtained in the above two investigations must be caused by something other than the difference in procedure to estimate the thermal expansion of rubidium chloride at low temperatures. Table III shows that the close agreement between the values of C_{11} and C_{44} as a function of temperature obtained in these two investigations is lacking with respect to C_{12} . Whereas the values of C_{12} reported by Marshall *et al.*⁹ increase with a decrease in temperature and remain unchanged below 200°K, our values of C_{12} decrease with a decrease in temperature and show no sign of levelling off to 100°K. We have no satisfactory explanation for the disagreement in the values of C_{12} as indicated above. However, there is some inferential support for the implausibility of the results reported by Marshall *et al.*⁹: (1) the contention of Marshall *et al.* that their results are consistent with the temperature dependence of C_{12} of alkali halides with NaCl structure does not hold, for the behaviors of the C_{12} of alkali halides with NaCl structure are more like that which we report for RbCl; (2) even though the

TABLE VI. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbCl as a function of pressure in units of kilobars at 259°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	3.749	3.674	0.609	0.533	0.471	1.654	1.580	0.0469	1.00000
0.320	3.792	3.718	0.612	0.536	0.469	1.671	1.597	0.0462	1.00067
0.602	3.830	3.756	0.616	0.541	0.468	1.686	1.613	0.0456	1.00126
0.998	3.887	3.814	0.623	0.544	0.465	1.707	1.634	0.0447	1.00207
1.515	3.958	3.885	0.628	0.555	0.462	1.737	1.665	0.0435	1.00312
1.995	4.023	3.951	0.637	0.562	0.459	1.764	1.692	0.0425	1.00408
2.485	4.089	4.018	0.643	0.569	0.456	1.790	1.719	0.0414	1.00504
3.015	4.158	4.088	0.648	0.578	0.452	1.818	1.748	0.0402	1.00606
3.540	4.229	4.160	0.659	0.585	0.450	1.846	1.777	0.0390	1.00706
4.035	4.291	4.223	0.671	0.593	0.446	1.872	1.803	0.0380	1.00799

TABLE VII. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbCl as a function of pressure in units of kilobars at 222°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	3.869	3.804	0.594	0.528	0.475	1.686	1.620	0.0406	1.00000
0.325	3.912	3.847	0.597	0.532	0.473	1.702	1.637	0.0400	1.00066
0.690	3.963	3.898	0.602	0.536	0.471	1.722	1.657	0.0394	1.00140
1.010	4.010	3.945	0.606	0.541	0.469	1.741	1.676	0.0388	1.00205
1.490	4.077	4.013	0.613	0.548	0.466	1.768	1.703	0.0379	1.00300
2.015	4.146	4.082	0.620	0.557	0.462	1.796	1.732	0.0370	1.00402
2.515	4.216	4.152	0.626	0.562	0.459	1.822	1.759	0.0361	1.00498
3.035	4.284	4.221	0.634	0.571	0.456	1.850	1.788	0.0351	1.00596
3.530	4.350	4.288	0.639	0.577	0.453	1.876	1.814	0.0342	1.00688

TABLE VIII. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbCl as a function of pressure (in units of kilobars) at 181°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	4.001	3.946	0.575	0.520	0.479	1.717	1.662	0.0333	1.00000
0.350	4.048	3.993	0.579	0.523	0.477	1.735	1.680	0.0328	1.00070
0.695	4.096	4.041	0.585	0.529	0.475	1.755	1.700	0.0323	1.00138
0.982	4.137	4.082	0.589	0.534	0.473	1.772	1.717	0.0319	1.00194
1.326	4.186	4.132	0.592	0.538	0.471	1.790	1.736	0.0314	1.00261
1.730	4.240	4.185	0.598	0.544	0.468	1.812	1.758	0.0309	1.00338
2.02	4.280	4.226	0.602	0.548	0.466	1.828	1.774	0.0305	1.00393
2.49	4.346	4.293	0.607	0.553	0.464	1.854	1.800	0.0298	1.00481

TABLE IX. Adiabatic elastic constants (in units of 10^{11} dyn/cm²) and parameter Δ and density (in units of g/cm³) of RbBr as a function of temperature (°K) as obtained in the present work (PW) and those obtained by Lewis, Lehoczy and Briscoe (LLB).

Temp.	C_{11}		C_{12}		C_{44}		Bulk modulus		Density		Δ
	PW	LLB	PW	LLB	PW	LLB	PW	LLB	PW	LLB	
	$\pm 0.16\%$		$\pm 0.2\%$		$\pm 0.16\%$						
300	3.152	3.107	0.5000	0.515	0.3801	0.3760	1.384		3.350	3.349	0.0496
280	3.204	3.164	0.494		0.382		1.397		3.357	3.356	0.0456
260	3.262	3.220	0.486		0.383		1.412		3.364	3.363	0.0415
240	3.317	3.276	0.480		0.385		1.426		3.371	3.370	0.0376
220	3.373	3.334	0.473		0.387		1.440		3.378	3.377	0.0337
200	3.430	3.390	0.465		0.388		1.453		3.385	3.384	0.0297
180	3.488	3.446	0.459		0.390		1.469		3.392	3.391	0.0259
160	3.542	3.503	0.451		0.391		1.481		3.398	3.398	0.0227
140	3.597	3.559	0.444		0.393		1.495		3.404	3.404	0.0193
120											
100											
80		3.725		0.474		0.4050				3.424	
60		3.775		0.474		0.4068				3.428	
40		3.820		0.474		0.4076				3.432	
20		3.853		0.474		0.483				3.434	
10		3.860		0.474		0.4085				3.434	
4		3.863		0.474		0.4085				3.434	

TABLE X. Temperature derivatives of the adiabatic elastic constants (in units of 10^7 dyn/cm² °K) of RbBr at room temperature.

	Temperature (°K)	C_{11}	C_{12}	C_{44}	Bulk modulus
Present work	300	-28.18	3.55	-0.817	-7.03

temperature at which the $(\partial C_{ij}/\partial T)_{P \rightarrow 0}$ is not necessarily the same for all the elastic constants, in relation to Debye temperatures at 0°K, the value of $(\partial C_{12}/\partial T)_P$ of RbCl as obtained by Marshall *et al.*⁹ goes to 0 at a temperature rather higher than that found for other halides. Thus, it seems that the behavior of the C_{12} with temperature as obtained by Marshall *et al.*⁹ is not in agreement with the results obtained on the other alkali halides. Moreover, the plausibility of the results of the present investigation may be further illustrated by a comparison of the temperature derivatives of C_{ij} obtained here, and in Refs. 9 and 10 (Table IV). The derivatives of our C_{ij} 's are in excellent agreement with those of Haussühl.¹⁰

The variation of the elastic constants of RbCl as a function of pressure has been investigated on a single crystal by Voronov *et al.*¹⁴ at 298°K, and on a polycrystalline specimen of RbCl by Voronov and Goncharova¹⁵ to 20 kbar. In the present work we report the pressure dependence of single-crystal elastic constants of RbCl to 4 kbar at 304°, 260°, 222°, and 180°K. Tables V–VIII give the values of these elastic constants, and the parameters $\Delta(P, T)$ and $\lambda(P, T)$ of RbCl as a function of pressure at each of the four temperatures mentioned.

A comparison with the results of Voronov *et al.*¹⁴ reveals that the pressure derivative of C_{11} and C_{44} as obtained by them are 12.52 and -0.602 against our values of 13.74 and -0.613 for C_{11} and C_{44} respectively.

TABLE XI. Adiabatic elastic constants (in units of 10^{11} dyn/cm²) isothermal pressure derivatives of the adiabatic elastic constants of RbBr at 300°K.

	Present work	Reddy and Ruoff
Elastic constants		
C_{11}	3.152	3.155
C_{12}	0.500	0.493
C_{44}	0.380	0.380
Pressure derivative		
C_{11}	13.63	13.52
C_{12}	1.46	3.049
C_{44}	-0.587	-0.362

These two sets of values are in good agreement. We have not compared the values of the pressure derivatives of C_{12} because Voronov *et al.*¹⁴ base their estimate of the same on the value of bulk modulus obtained by Voronov and Goncharova¹⁵ on a polycrystalline specimen of RbCl.

RUBIDIUM BROMIDE

The temperature dependence of the elastic constants of rubidium bromide at one atmosphere has been studied by Lewis *et al.*¹⁶ between 4.2° and 300°K and by Haüssühl¹⁰ at higher temperatures. The results of

TABLE XII. Isothermal pressure derivatives of the adiabatic elastic constants of alkali halides with NaCl structure at room temperature.

	F	Cl	Br	I
C_{11}				
Li	9.97 ^d	10.43 ^e	10.43 ^e	
Na	11.77 ^d	11.66 ^a	11.50 ^b	13.99
K	11.74 ^b	12.82 ^a	12.96 ^f	14.56 ^f
Rb		13.73 ^e	13.62 ^e	13.39 ^e
C_{12}				
Li	2.73 ^d	2.89 ^e	2.83 ^e	
Na	2.19 ^d	2.08 ^a	1.68 ^b	2.421
K	1.66 ^b	1.60 ^a	1.59 ^f	2.45 ^f
Rb		1.34 ^e	1.46 ^e	1.307 ^e
C_{44}				
Li	1.38 ^d	1.68 ^e	1.71 ^e	
Na	0.205 ^d	0.37 ^a	0.423 ^b	-0.241
K	-0.452 ^b	-0.39 ^a	-0.328 ^f	-0.237 ^f
Rb		-0.61 ^e	-0.587 ^e	-0.522 ^e

^a R. A. Bartels and D. S. Schuele, *J. Phys. Chem. Solids* **26**, 537 (1965).

^b Reference 1.

^c Li-Shiu Ching, Ph.D. thesis, Cornell University, Ithaca, N. Y., 1968.

^d R. A. Miller and C. S. Smith, *J. Phys. Chem. Solids* **25**, 1279 (1964).

^e Present work.

^f Reference 4.

the present investigation are compared with those of Lewis *et al.* in Table IX.

In the calculation of the elastic constants, the density of RbBr at 300°K is assumed to be 3.4498 g/cm³. The values of volume thermal-expansion coefficients are obtained from the paper of James and Yates.¹⁷ The values at 260° and 300°K are extrapolated from these low-temperature values. The low-temperature specific-heat values are taken from Clusius *et al.*¹⁸

The values of the elastic constants of RbBr thus obtained are in good agreement with those obtained in Ref. 16, as are the temperature derivatives of these constants. The temperature derivatives of the present investigation are given in Table X.

TABLE XIII. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbBr as a function of pressure (in kilobars) at 300°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	3.151	3.086	0.500	0.434	0.380	1.383	1.318	0.0497	1.00000
0.600	3.234	3.169	0.508	0.443	0.377	1.416	1.352	0.0479	1.00150
1.200	3.318	3.254	0.516	0.452	0.373	1.450	1.386	0.0461	1.00296
1.800	3.402	3.339	0.526	0.463	0.370	1.485	1.422	0.0443	1.00439
2.400	3.484	3.422	0.533	0.471	0.366	1.517	1.455	0.0425	1.00579
2.600	3.512	3.450	0.536	0.475	0.365	1.528	1.467	0.0419	1.00625
2.800	3.539	3.478	0.538	0.478	0.364	1.539	1.478	0.0413	1.00671
3.015	3.566	3.505	0.542	0.481	0.362	1.550	1.489	0.0406	1.00719
3.220	3.590	3.530	0.546	0.486	0.361	1.561	1.501	0.0400	1.00765
3.400	3.617	3.557	0.550	0.489	0.360	1.572	1.512	0.0395	1.00806
3.610	3.646	3.586	0.551	0.491	0.359	1.583	1.523	0.0388	1.00852
3.800	3.670	3.611	0.555	0.497	0.358	1.594	1.535	0.0382	1.00894
4.010	3.697	3.639	0.558	0.499	0.356	1.604	1.546	0.0376	1.00940

The pressure dependence of the elastic constants of rubidium bromide has been investigated only by Reddy and Ruoff⁴ and only at 300°K. The present work extends the measurement of the pressure dependence of the elastic constants down to 180°K. Since the present investigation and that of Ref. 4 have been conducted in the same laboratory by the identical method, a comparison of results obtained in these investigations

is of added interest. The values of the elastic constants and their pressure derivatives at 300°K as obtained in these two works are displayed in Table XI. It shows that the agreement between these two sets of values of the C_{ij} of RbBr at 300°K is excellent. However, this kind of agreement is not present when one compares the values of the pressure derivatives of these constants. The discrepancy is at its worst in the case

TABLE XIV. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbBr as a function of pressure (in kilobars) at 260°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	3.257	3.201	0.482	0.426	0.383	1.407	1.351	0.0417	1.00000
0.210	3.286	3.230	0.486	0.429	0.382	1.419	1.363	0.0412	1.00052
0.400	3.310	3.254	0.488	0.432	0.381	1.429	1.373	0.0407	1.00098
0.600	3.338	3.283	0.494	0.437	0.380	1.442	1.386	0.0402	1.00146
0.800	3.365	3.310	0.496	0.440	0.379	1.452	1.397	0.0397	1.00194
1.000	3.395	3.340	0.499	0.443	0.377	1.464	1.409	0.0392	1.00242
1.200	3.421	3.366	0.502	0.447	0.376	1.475	1.420	0.0387	1.00289
1.400	3.450	3.395	0.505	0.450	0.375	1.487	1.432	0.0382	1.00336
1.600	3.477	3.422	0.508	0.453	0.374	1.498	1.443	0.0378	1.00383
1.800	3.503	3.449	0.511	0.456	0.373	1.509	1.454	0.0373	1.00429
2.000	3.531	3.477	0.515	0.460	0.371	1.520	1.466	0.0368	1.00475
2.200	3.558	3.504	0.518	0.463	0.370	1.531	1.477	0.0363	1.00520
2.400	3.584	3.531	0.521	0.468	0.369	1.542	1.489	0.0358	1.00565
2.600	3.612	3.559	0.524	0.470	0.368	1.553	1.500	0.0353	1.00610
2.800	3.639	3.587	0.527	0.474	0.367	1.565	1.512	0.0348	1.00655
3.000	3.665	3.613	0.530	0.478	0.365	1.575	1.523	0.0344	1.00699
3.200	3.687	3.635	0.534	0.482	0.364	1.585	1.533	0.0338	1.00743
3.400	3.714	3.662	0.537	0.485	0.363	1.596	1.544	0.0334	1.00787
3.600	3.741	3.690	0.540	0.489	0.362	1.607	1.556	0.0329	1.00830
3.800	3.768	3.717	0.542	0.492	0.360	1.617	1.567	0.0324	1.00873

TABLE XV. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbBr as a function of pressure (in kilobars) at 220°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	3.369	3.322	0.471	0.424	0.386	1.437	1.390	0.0339	1.00000
0.200	3.397	3.350	0.474	0.426	0.385	1.448	1.401	0.0335	1.00048
0.400	3.424	3.377	0.478	0.431	0.384	1.460	1.413	0.0331	1.00095
0.600	3.453	3.407	0.480	0.434	0.383	1.471	1.425	0.0327	1.00142
0.800	3.481	3.435	0.483	0.436	0.382	1.482	1.436	0.0323	1.00189
1.000	3.511	3.465	0.486	0.439	0.380	1.494	1.448	0.0319	1.00235
1.200	3.538	3.492	0.490	0.444	0.379	1.505	1.460	0.0315	1.00281
1.400	3.568	3.522	0.492	0.447	0.378	1.518	1.472	0.0311	1.00327
1.600	3.594	3.549	0.495	0.450	0.377	1.528	1.483	0.0307	1.00372
1.800	3.622	3.576	0.499	0.453	0.376	1.540	1.494	0.0303	1.00417
2.000	3.648	3.603	0.502	0.457	0.374	1.551	1.506	0.0299	1.00462
2.200	3.676	3.631	0.504	0.460	0.373	1.562	1.517	0.0295	1.00506
2.400	3.704	3.660	0.506	0.462	0.372	1.572	1.528	0.0291	1.00550
2.615	3.732	3.688	0.509	0.464	0.371	1.584	1.539	0.0286	1.00597
2.800	3.758	3.714	0.508	0.465	0.370	1.591	1.548	0.0283	1.00637
3.000	3.785	3.742	0.509	0.466	0.368	1.601	1.558	0.0279	1.00680
3.200	3.812	2.769	0.510	0.467	0.367	1.611	1.568	0.0275	1.00723
3.415	3.837	3.794	0.514	0.471	0.366	1.621	1.579	0.0270	1.00769
3.610	3.864	3.822	0.515	0.472	0.365	1.631	1.589	0.0267	1.00811
3.810	3.892	3.850	0.516	0.473	0.363	1.642	1.599	0.0263	1.00853

of the pressure derivative of C_{12} , and such a discrepancy cannot be reconciled even when generous allowances are made for the uncertainties in the measurement and control of the experimental observables. We do not have an easy and definite explanation for this disagreement. However, we feel that the results of the

present work are the more plausible of the two when the trend in the values of the pressure derivatives of the elastic constants of the other alkali halides having NaCl structure at room temperature is taken into consideration (Table XII). The sources of the data presented in Table XII are listed underneath this table.

TABLE XVI. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbBr as a function of pressure (in kilobars) at 180°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	3.488	3.451	0.459	0.421	0.390	1.468	1.431	0.0262	1.00000
0.200	3.513	3.476	0.462	0.425	0.389	1.479	1.442	0.0259	1.00046
0.400	3.540	3.503	0.463	0.425	0.387	1.488	1.451	0.0256	1.00092
0.600	3.565	3.528	0.464	0.427	0.386	1.498	1.461	0.0252	1.00138
0.800	3.590	3.553	0.466	0.430	0.385	1.507	1.471	0.0249	1.00184
1.000	3.615	3.578	0.466	0.429	0.384	1.515	1.479	0.0246	1.00229
1.200	3.640	3.604	0.467	0.431	0.383	1.525	1.489	0.0243	1.00274
1.400	3.667	3.631	0.470	0.434	0.381	1.536	1.500	0.0240	1.00319
1.600	3.693	3.657	0.470	0.434	0.380	1.544	1.508	0.0236	1.00364
1.800	3.720	3.684	0.475	0.439	0.379	1.556	1.521	0.0233	1.00408
2.000	3.748	3.713	0.480	0.444	0.378	1.569	1.534	0.0230	1.00452
2.200	3.772	3.738	0.478	0.442	0.377	1.576	1.541	0.0227	1.00495
2.400	3.802	3.767	0.484	0.449	0.376	1.590	1.555	0.0224	1.00538

TABLE XVII. Adiabatic elastic constant (in units of 10^{11} dyn/cm²) and parameter Δ and density (in units of g/cm³) of RbI as a function of temperature ($^{\circ}$ K) as obtained in the present work (PW) and those obtained by Haussuhl.

Temperature ($^{\circ}$ K)	C_{11}		C_{12}		C_{44}		Bulk modulus	Δ	Density
	PW	Haussuhl	PW	Haussuhl	PW	Haussuhl			
300	2.556		0.382		0.278		1.107	0.0560	3.551
295	...	2.583	...	0.37	...	0.278			3.553
260	2.652		0.364		0.280		1.127	0.0474	3.569
240	2.699		0.358		0.281		1.138	0.0434	3.577
220	2.747		0.351		0.282		1.153	0.0395	3.585
200	2.798		0.342		0.283		1.160	0.0348	3.594
180	2.850		0.335		0.284		1.174	0.0309	3.602
160	2.891		0.329		0.285		1.183	0.0267	3.610
140	2.948		0.318		0.286		1.194	0.0227	3.618
120	2.988		0.314		0.287		1.206	0.0185	3.625

TABLE XVIII. Temperature derivatives of adiabatic elastic constants (in units of 10^7 dyn/cm² $^{\circ}$ K) of RbI at room temperature.

	Temperature ($^{\circ}$ K)	C_{11}	C_{12}	C_{44}	Bulk modulus
Present work	300	-24.16	3.28	-0.555	-5.87
Haussuhl	295	-24.95	3.22	-0.573	-6.17
Lewis <i>et al.</i>	300	-42.61	0.00	-0.530	-14.20

TABLE XIX. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbI as a function of pressure (in kilobars) at 300 $^{\circ}$ K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	2.557	2.498	0.377	0.318	0.277	1.103	1.045	0.0560	1.00000
0.200	2.584	2.526	0.379	0.321	0.276	1.114	1.056	0.0551	1.00064
0.400	2.612	2.554	0.382	0.323	0.275	1.125	1.067	0.0543	1.00126
0.600	2.640	2.582	0.384	0.326	0.274	1.136	1.078	0.0534	1.00189
0.800	2.667	2.610	0.387	0.330	0.273	1.147	1.090	0.0526	1.00250
1.000	2.697	2.640	0.389	0.331	0.272	1.158	1.101	0.0517	1.00311
1.200	2.722	2.666	0.391	0.335	0.271	1.168	1.112	0.0509	1.00372
1.400	2.749	2.693	0.395	0.339	0.270	1.180	1.124	0.0500	1.00432
1.600	2.776	2.720	0.397	0.341	0.269	1.190	1.134	0.0492	1.00491
1.800	2.804	2.748	0.400	0.343	0.268	1.201	1.145	0.0484	1.00550
2.000	2.831	2.776	0.403	0.347	0.267	1.212	1.157	0.0475	1.00608
2.200	2.857	2.802	0.405	0.351	0.266	1.222	1.168	0.0467	1.00666
2.400	2.883	2.829	0.408	0.357	0.265	1.233	1.179	0.0458	1.00723
2.600	2.910	2.856	0.410	0.357	0.264	1.244	1.190	0.0450	1.00780
2.800	2.936	2.883	0.413	0.360	0.263	1.254	1.201	0.0441	1.00836
3.000	2.963	2.910	0.416	0.363	0.262	1.265	1.212	0.0433	1.00892
3.200	2.988	2.936	0.418	0.366	0.261	1.275	1.223	0.0424	1.00947
3.400	3.013	2.962	0.421	0.370	0.260	1.285	1.234	0.0416	1.01002
3.600	3.040	2.989	0.424	0.373	0.258	1.296	1.245	0.0408	1.01056
3.800	3.066	3.016	0.426	0.376	0.258	1.306	1.256	0.0399	1.01110

TABLE XX. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbI as a function of pressure (in kilobars) at 260°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	2.650	2.598	0.368	0.316	0.279	1.128	1.077	0.0474	1.00000
0.200	2.677	2.626	0.369	0.319	0.278	1.138	1.088	0.0468	1.00062
0.400	2.705	2.655	0.371	0.321	0.277	1.149	1.099	0.0461	1.00123
0.600	2.734	2.683	0.373	0.322	0.276	1.160	1.109	0.0454	1.00183
0.800	2.762	2.712	0.376	0.325	0.275	1.171	1.121	0.0447	1.00243
1.000	2.791	2.741	0.378	0.327	0.274	1.182	1.132	0.0440	1.00302
1.250	2.824	2.775	0.381	0.331	0.273	1.196	1.146	0.0432	1.00376
1.500	2.861	2.812	0.384	0.334	0.271	1.210	1.160	0.0423	1.00448
1.750	2.894	2.846	0.386	0.338	0.270	1.222	1.174	0.0414	1.00520
2.000	2.929	2.880	0.390	0.342	0.269	1.236	1.188	0.0406	1.00591
2.250	2.963	2.915	0.392	0.344	0.268	1.249	1.201	0.0397	1.00661
2.500	2.996	2.949	0.395	0.348	0.266	1.262	1.215	0.0388	1.00731
2.750	3.031	2.984	0.397	0.350	0.265	1.275	1.228	0.0380	1.00799
2.990	3.062	3.015	0.401	0.355	0.264	1.288	1.242	0.0372	1.00865
3.250	3.096	3.050	0.404	0.359	0.262	1.301	1.256	0.0363	1.00935
3.500	3.129	3.084	0.407	0.361	0.261	1.314	1.269	0.0354	1.01001
3.750	3.162	3.118	0.409	0.364	0.259	1.326	1.282	0.0346	1.01067

It may be seen that the value of the pressure derivative of C_{12} as obtained by Reddy and Ruoff⁴ is not consistent with the trend in the values of the pressure derivatives of C_{12} of other halides or other alkali bromides. The other pressure derivatives obtained by Reddy and Ruoff are, however, consistent. On the other hand all the pressure derivatives obtained by us are consistent with the results of the other alkali halides. In the light of the above and due to this single disagreement between the results of these two works, we suspect that Reddy and Ruoff just missed a factor of 2 somewhere in the computation of the pressure derivative of C_{12} . This is suggested because where an adjustment is accordingly made in the estimated value of the pressure derivative of C_{12} given in Ref. 4, the single discrepancy in the two sets of data on RbBr disappears. This adjusted value of the pressure derivative of C_{12} turns out to be 1.52, which agrees well with our value of 1.46 for the same.

In Tables XIII–XVI we present the values of the elastic constants of rubidium bromide as a function of pressure at 300°, 260°, 220°, and 180°K, respectively.

RUBIDIUM IODIDE

The variation in the elastic constants of rubidium iodide as a function of temperature has been investigated by Haussühl¹⁰ between approximately 250° and 373°K. We have investigated this variation of the elastic constants from 120° to 300°K and Lewis *et al.*¹⁶ have done so from 4.2° to 300°K. In the computation of the elastic constants, presented in Table XVII we

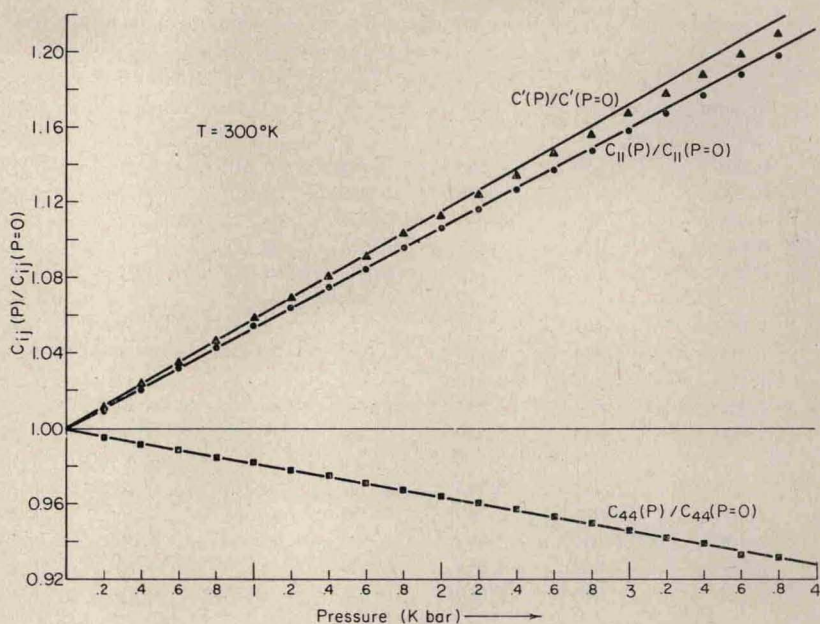
have assumed a value of 3.551 g/cm³ as the density of RbI at 300°K. The values of volume thermal expansion coefficients at low temperatures are obtained from the work of Schuele and Smith.¹⁹ Since they report the values of the linear thermal expansion coefficient only to 235°K, we had to extrapolate the values of these coefficients to estimate their values in the temperature interval 235° to 300°K. The values of the specific heat are obtained from Ref. 18. The elastic constants thus obtained are given in Table XVII. The values of the elastic constants and their temperature derivatives at 300°K are in good agreement with the results obtained by Haussühl but not with those of Lewis *et al.* with respect to the temperature derivatives of C_{11} and C_{12} (Table XVIII). The variation of the elastic constants of RbI is smooth and linear with temperature down to 120°K.

The pressure dependence of the elastic constants of RbI has been investigated at 300°, 260°, 220°, and 180°K and the results are presented in Tables XIX–XXII. The variation of elastic constants of RbI as a function of temperature and pressure are plotted in Figs. 1 and 2. The variation for RbCl and RbBr are similar. The only available information about the pressure dependence of the elastic constants are given in terms of γ_i .¹⁹ We have calculated the values of γ_i from our data. These γ_i have been calculated from the relation

$$\gamma_i = -\frac{1}{6} + (B^T/2C_i)(\partial C_i/\partial P)_T,$$

where B^T is isothermal bulk modulus and C_i is the

FIG. 1. Relative variation of the adiabatic elastic constants of RbI as a function of hydrostatic pressure at $T = 300^\circ\text{K}$.



elastic constant associated with the i th branch of the vibrational spectrum. Table XXIII indicates that the values of γ_i as obtained here and by Schuele and Smith¹⁹ are in good agreement.

PRESSURE DERIVATIVES

Tables XXIV-XXVI give the values of dC_{ij}/dP for different thermodynamic conditions (see Ref. 20)

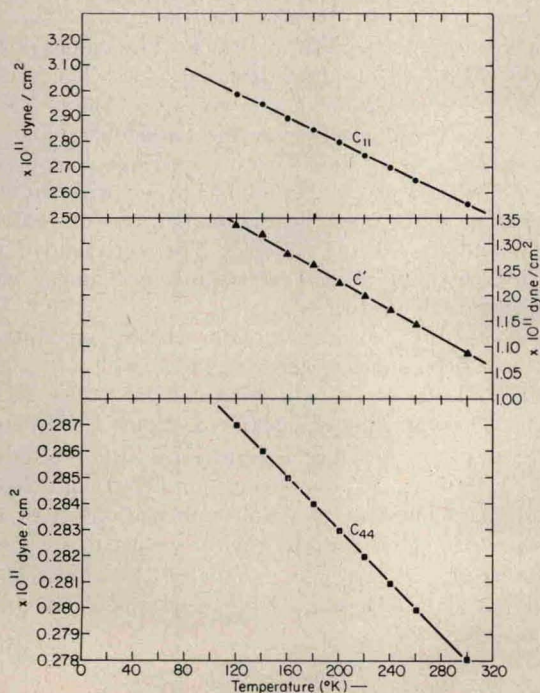


FIG. 2. Adiabatic elastic constants of RbI as a function of temperature.

and for the three rubidium halides at four different temperatures.

Anisotropy

We will use our results to consider how the anisotropy ratio

$$A = 2C_{44}/(C_{11} - C_{12})$$

varies with temperatures and pressure. These results are shown in Table XXVII.

The anisotropy ratio is unity for isotropic solids. Hence a value of other than one is indicative of the anisotropy of the material. Reinitz,²¹ while discussing the anisotropy of alkali halides at room temperature concluded that (i) the anisotropy is influenced by the alkali ion, and (ii) the nature of the halide ion has more effect on the anisotropy as the size of the alkali ion increases. Table XXVII presents the values of A of the three rubidium halides as a function of pressure and temperature. It shows that the anisotropy of the rubidium halides increases with a decrease in temperature and/or with an increase in pressure. The temperature dependence of the anisotropy seems to be independent of pressure and does not seem to be affected by the nature of the halide ion in the rubidium halides. But the pressure dependence of this factor in the rubidium halides is dependent on both the temperature and the nature of the halide ion in these salts. The temperature dependence of A 's in these halides is not weakly dependent on temperature as stated by Nikanorov *et al.*^{22,23} in their paper dealing with the temperature dependence of the anisotropy of alkali halides with NaCl structure. Our results show A to be strongly temperature dependent.

TABLE XXI. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbI as a function of pressure (in kilobars) at 220°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	2.749	2.705	0.351	0.308	0.282	1.150	1.107	0.0395	1.00000
0.175	2.772	2.728	0.352	0.309	0.281	1.159	1.115	0.0390	1.00052
0.410	2.805	2.762	0.355	0.311	0.280	1.172	1.128	0.0384	1.00122
0.600	2.831	2.787	0.357	0.315	0.279	1.182	1.139	0.0378	1.00178
0.800	2.858	2.815	0.360	0.317	0.278	1.192	1.150	0.0373	1.00237
1.000	2.885	2.843	0.362	0.320	0.276	1.204	1.161	0.0367	1.00295
1.200	2.911	2.868	0.364	0.322	0.276	1.213	1.171	0.0362	1.00352
1.400	2.940	2.898	0.367	0.325	0.274	1.225	1.183	0.0356	1.00409
1.600	2.965	2.923	0.368	0.326	0.273	1.234	1.192	0.0351	1.00465
1.800	2.993	2.951	0.372	0.330	0.272	1.246	1.204	0.0345	1.00521
2.000	3.018	2.977	0.374	0.332	0.271	1.255	1.214	0.0340	1.00577
2.200	3.043	3.002	0.375	0.335	0.270	1.265	1.224	0.0334	1.00632
2.400	3.072	3.032	0.379	0.338	0.269	1.277	1.236	0.0329	1.00686
2.600	3.097	3.057	0.380	0.339	0.268	1.286	1.245	0.0323	1.00740
2.800	3.125	3.085	0.385	0.346	0.267	1.299	1.259	0.0318	1.00794
3.000	3.149	3.109	0.384	0.345	0.266	1.306	1.266	0.0312	1.00847

Cauchy Relation

In a cubic crystal when the forces between the ions are of central type and have a single-body character, the ions are centers of symmetry. At zero pressure the Cauchy relation²⁴ $C_{12} = C_{44}$, is approximately realized for the alkali halides. Love²⁴ has shown that under an external pressure P , Cauchy relation is given by $C_{44}(P) = C_{12}(P) - 2P$. Here $C_{12}(P)$ and $C_{44}(P)$ are the effective elastic constants we measure at pressure P . The proof is simple and follows from Chung's

work.²⁵

$$C_{12}(P) = C_{12} + \eta(-C_{11} - C_{12} + 2C_{112} + C_{123}), \quad (23)$$

$$C_{44}(P) = C_{44} + \eta(C_{11} + 2C_{12} + C_{44} + C_{144} + 2C_{166}), \quad (24)$$

where

$$\eta = -P/3B.$$

At room pressure we have the following Cauchy relation for second- and third-order elastic constants.

$$C_{12} = C_{44}, \quad C_{123} = C_{456} = C_{144}, \quad C_{122} = C_{166}, \quad (25)$$

TABLE XXII. Adiabatic and isothermal elastic constants (in units of 10^{11} dyn/cm²) and the parameters Δ and λ of RbI as a function of pressure (in kilobars) at 178°K.

Pressure	C_{11}^S	C_{11}^T	C_{12}^S	C_{12}^T	C_{44}	B^S	B^T	Δ	λ
0.001	2.850	2.816	0.336	0.300	0.284	1.174	1.139	0.0306	1.00000
0.200	2.879	2.844	0.338	0.304	0.283	1.185	1.151	0.0302	1.00058
0.400	2.907	2.872	0.342	0.307	0.282	1.197	1.162	0.0298	1.00116
0.600	2.935	2.901	0.344	0.310	0.281	1.208	1.174	0.0294	1.00173
0.800	2.962	2.928	0.347	0.313	0.280	1.219	1.185	0.0290	1.00230
1.000	2.991	2.957	0.350	0.315	0.279	1.230	1.196	0.0285	1.00286
1.250	3.026	2.992	0.354	0.320	0.277	1.245	1.211	0.0280	1.00355
1.500	3.060	3.026	0.357	0.324	0.276	1.258	1.225	0.0275	1.00424
1.750	3.093	3.060	0.361	0.327	0.275	1.272	1.238	0.0270	1.00492
2.000	3.122	3.089	0.359	0.326	0.274	1.280	1.247	0.0264	1.00560
2.250	3.155	3.122	0.363	0.330	0.272	1.294	1.261	0.0259	1.00626
2.500	3.190	3.157	0.366	0.332	0.271	1.307	1.274	0.0254	1.00693
2.750	3.222	3.190	0.368	0.335	0.270	1.319	1.287	0.0249	1.00758
3.000	3.255	3.223	0.371	0.338	0.268	1.332	1.300	0.0244	1.00823

TABLE XXIII. Gruneisen γ_i for several modes of vibration in RbI at 300°K.

Direction of propagation		Longitudinal	Shear	
100	Present work	2.57	-1.15	-1.15
	Schuele and Smith	2.53	-1.06	-1.06
110	Present work	2.02	-1.15	+2.73
	Schuele and Smith	1.91	-1.06	+2.56
111	Present work	1.51	2.29	2.29
	Schuele and Smith	1.54	2.15	2.15

subtracting (24) from (23) and using (25) we get the Cauchy-Love relation

$$C_{44}(P) = C_{12}(P) - 2P. \quad (26)$$

The ratio $P=0$

$$\delta = C_{12}/C_{44} \quad (27)$$

for RbCl, RbBr, and RbI is given in Table XXVII. For $P=0$, $\delta=1$ for a central-force crystal. The derivative of Eq. (26) gives

$$\frac{1}{2}[(dC_{12}/dP) - (dC_{44}/dP)] = 1$$

for a central force crystal. The measured quantity

$$\frac{1}{2}[(dC_{12}/dP) - (dC_{44}/dP)]$$

for the three salts at different temperatures is given in Table XXVII.

First, we notice that δ does not assume a value of one for any of the halides within the range of variation in temperature as represented in Table XXVII. However, the values of δ tend towards one as the temperature decreases. The Cauchy-Love relation in the form of Eq. (28) is also approximately satisfied.

TABLE XXIV. Isothermal pressure derivatives of the adiabatic elastic constants of RbCl, RbBr, and RbI as a function of temperature (°K).

	Temperature (°K)	C_{11}	C_{12}	C_{44}	Bulk modulus
RbCl	304	13.74	1.342	-0.613	5.47
	260	13.51	1.395	-0.632	5.44
	222	13.66	1.310	-0.636	5.42
	180	13.90	1.313	-0.616	5.51
RbBr	300	13.62	1.460	-0.587	5.52
	260	13.46	1.577	-0.596	5.54
	220	13.69	1.172	-0.602	5.35
	180	13.02	0.938	-0.594	4.97
RbI	300	13.39	1.307	-0.522	5.33
	260	13.70	1.261	-0.529	5.32
	220	13.37	1.153	-0.535	5.22
	180	13.44	1.134	-0.527	5.23

TABLE XXV. Isothermal pressure derivatives of isothermal elastic constants of RbCl, RbBr, and RbI as a function of temperature (°K).

	Temperature (°K)	C_{11}	C_{12}	C_{44}	Bulk modulus
RbCl	304	13.91	1.517	-0.613	5.65
	260	13.65	1.532	-0.632	5.57
	222	13.76	1.414	-0.636	5.53
	180	13.96	1.378	-0.616	5.57
RbBr	300	13.81	1.643	-0.587	5.70
	260	13.61	1.722	-0.596	5.68
	220	13.83	1.308	-0.602	5.48
	180	13.14	1.053	-0.594	5.08
RbI	300	13.61	1.527	-0.522	5.55
	260	13.88	1.307	-0.529	5.50
	220	13.51	1.292	-0.535	5.36
	180	13.54	1.241	-0.527	5.34

We have not compared the values of δ as obtained by Dick²⁶ for two reasons: (1) his calculations refer to 4.2°K, and (2) according to him his calculations of δ are expected to be more reliable when the positive ion is small compared to the negative ion in the alkali halide crystals.

SUMMARY OF THE RESULTS

The main features of the results presented on RbCl, RbBr, and RbI are:

(i) The variation in the elastic constants of these halides with pressure and temperature is linear.

(ii) Whereas the values of C_{11} and C_{12} increase with

TABLE XXVI. Adiabatic pressure derivatives of adiabatic elastic constants of RbCl, RbBr, and RbI as a function of temperature (°K).

	Temperature (°K)	C_{11}	C_{12}	C_{44}	Bulk modulus
RbCl	304	12.84	1.441	-0.640	5.24
	260	12.74	1.480	-0.655	5.24
	222	13.00	1.383	-0.656	5.25
	180	13.36	1.372	-0.632	5.37
RbBr	300	12.72	1.573	-0.613	5.30
	260	12.70	1.672	-0.618	5.35
	220	13.07	1.250	-0.620	5.19
	180	12.52	1.000	-0.608	4.85
RbI	300	12.39	1.443	-0.545	5.09
	260	12.85	1.377	-0.548	5.11
	220	12.66	1.249	-0.551	5.05
	180	12.87	1.211	-0.540	5.09

TABLE XXVII. Elastic anisotropy factor A and δ and $\frac{1}{2}(dC_{12}^T/dP - dC_{44}/dP)$ as a function of temperature and pressure for RbCl, RbBr, and RbI.

	Temp. (°K)	A			$\delta = C_{12}^T/C_{44}$ $P=0$	$\frac{1}{2}[(dC_{12}^T/dP)_T - (dC_{44}/dP)_T]$
		Pressure 0.001	(kbar) 3.0			
RbCl	300	0.311	0.266	1.152	1.065	
	180	0.279	0.243	1.086	0.997	
RbBr	300	0.287	0.239	1.142	1.115	
	180	0.258	0.220	1.079	0.823	
RbI	300	0.255	0.205	1.150	1.025	
	180	0.266	0.185	1.058	0.884	

increasing pressure, those of C_{44} decrease with increasing pressure at all temperatures. Also, C_{44} is weakly dependent on pressure in comparison to C_{11} and C_{12} .

(iii) Whereas the values of C_{11} and C_{44} increase with a decrease in temperature at any pressure P , the values of C_{12} decrease with a decrease in temperature at a pressure P .

(iv) The elastic constants of RbI as a function of temperature and pressure are plotted in Figs. 1 and 2 to show the validity of the results (i), (ii), (iii). The other two salts behave the same way.

(v) The values of Δ decrease linearly with an increase in pressure or decrease in temperature.

(vi) Table XXIV indicates that the pressure derivatives of the elastic constants of these halides generally changes slightly between 300° and 180°K.

(vii) The linear behavior of λ with pressure and temperature indicates that to detect the presence of the nonlinear behavior of these halides, if any, the measurements necessary are to be more precise, or to the limit of the respective transition pressures of these halides, their equation of state may be represented by

$$B(T, P) = B(300^\circ, 1) + [\partial B(T, P)/\partial T]_{P=1} \times (T - 300) + [\partial B(T, P)/\partial P]_{T=300} (P - 1),$$

where $B(T, P)$ is the bulk modulus at a temperature T (°K) and pressure P (bars).

(viii) The values of anisotropic factor tend to deviate away from unity with either a decrease in temperature or/and an increase in pressure. The difference in the values of this factor for the three halides at any temperature or pressure confirms the observation of Reinitz.

(ix) An increase in temperature tends to increase the value of parameter $\delta = C_{12}/C_{44}$.

Note: The theoretical investigation of the present work is the subject of the next paper.

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