the constant-pressure specific heat, C_p,[13] derived from measurements on the saturated liquid. If the relations hold at higher pressures, then for the limits $5\times10^{-2} < |P-P_\lambda| < 10$ atm or $5\times10^{-4} < |T-T_\lambda| < 10^{-1}$ °K, β tends to vary linearly with α_P and C_p, which is consistent with the Buckingham-Fairbank[14] derivations. Unfortunately, the experimental ranges of pressure do not overlap. Therefore direct comparisons between the data cannot be made. However, at the λ point of 2.023°K and 13.04 atm Lounasmaa[4] found that β, measured with 10^{-3} atm resolution, varied linearly with $|P-P_\lambda|$ for $10^{-3} < |P-P_\lambda| < 10^{-2}$ atm. At $|P-P_\lambda| = 10^{-3}$ atm, his results coincide with the values from Eqs. (3) and (5), namely, $\beta_- = 8.8$ and $\beta_+ = 7.9$ in 10^{-3} atm^{-1} units. At $|P-P_\lambda| = 10^{-2}$ atm, the agreement is poorer but still acceptable. It is notable that the highest values of β observed near a λ point are only $\sim10^{-2}$ atm^{-1}.

TABLE II. Constants in Eq. (5).

T (°K)	P_λ (atm)	a_- (atm^{-1})	b_- (atm^{-1})	a_+ (atm^{-1})	b_+ (atm^{-1})
2.050	10.92	0.75	0.42	0.16	0.34
2.000	14.62	0.93	0.48	0.20	0.41
1.949	18.27	1.08	0.58	0.25	0.46
1.899	21.65	1.38	0.74	0.55	0.53
1.880	22.86	1.52	0.77	0.55	0.44
1.865	23.81	1.78	0.92	0.58	0.53
1.799	27.74	1.79	1.23	0.62	0.60

Therefore, the validity of an expression like Eq. (5) cannot continue indefinitely as the λ point is approached. Goldstein[15] pointed out that the root-mean-square temperature fluctuations of the system, the upper limit of meaningful $|T-T_\lambda|$ values, is $\sim10^{-12}$°K.

The sound velocities of Atkins and Stasior[2] were combined with the densities of Keesom and Keesom[1] to derive the adiabatic compressibilities, $\beta_S = (\rho u^2)^{-1}$. Although the velocities should have high resolution, no anomalous variation of β_S with pressure was seen near the λ transition. The β_S values were combined with the present isothermal compressibilities to derive $C_P/C_V = \beta/\beta_S$, the ratio of specific heats. Figure 9 shows C_P/C_V rising with pressure, reaching peaks of ~1.6 at the λ transition, before dropping to the values at 2.20°K, which are at most 1.05. The peak heights of the C_P/C_V ratio are indefinite, as are those of β, whereas the derivations of Buckingham and Fairbank[14] indicate that if $C_P \to \infty$, $\beta \to \infty$ while C_V and β_S remain finite. However, this behavior of C_V and β_S can be questioned if the λ transition is connected with the liquid-gas critical point [see Tisza[16] and Green[17]]. As the critical point is approached, singular functions are indicated for β_S and C_V by Chase, Williamson, and Tisza[18] and by Moldover and Little,[19] respectively. Therefore, the functions for β_S and C_V might be similar enough to those for β and C_P that $C_P/C_V = \beta/\beta_S$ remains finite at the λ transition.

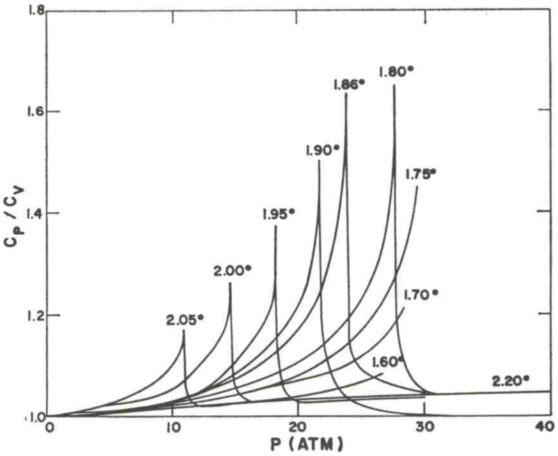

FIG. 9. The ratio of specific heats C_P/C_V versus pressure for liquid He^4 at several temperatures.

ACKNOWLEDGMENT

It is a pleasure to thank Dr. Louis Goldstein for his interest, suggestions, and encouragement in this investigation.

---

[13] W. M. Fairbank, M. J. Buckingham, and C. F. Kellers, in *Low Temperature Physics and Chemistry*, edited by J. K. Dillinger (University of Wisconsin Press, Madison, Wisconsin, 1958), p. 50.

[14] M. J. Buckingham and W. M. Fairbank, in *Progress in Low Temperature Physics*, edited by C. J. Gorter (North-Holland Publishing Company, Amsterdam, 1961), Vol. 3, Chap. III.

[15] L. Goldstein, Phys. Rev. **135**, A1471 (1964); **137**, AB4(E) (1965).

[16] L. Tisza, Ann. Phys. (N. Y.) **13**, 1 (1961).

[17] M. S. Green, Science **150**, 229 (1965).

[18] C. E. Chase, R. C. Williamson, and L. Tisza, Phys. Rev. Letters **13**, 467 (1964).

[19] M. R. Moldover and W. A. Little, Phys. Rev. Letters **15**, 54 (1965).