$$\frac{n^2-1}{n^2+2} = \frac{4\pi}{3M}(N_0\alpha) \tag{3.1}$$

through the molar polarizability ($N_0\alpha$). The single important assumption in the following analysis is that this molar polarizability is independent of density or temperature. The evidence on which we base this assumption is as follows. Edwards (1957) showed that, for saturated helium vapor, ($N_0\alpha$) is constant from 1.5° K to 4.2° K and equal to (0.1245 ± 0.0005) cm^3 mole^{-1} for $\lambda = 5462.27$ Å. He also calculated that, for helium gas at N.T.P., ($N_0\alpha$) is (0.1246 ± 0.0002) cm^3 mole^{-1} for $\lambda = 5462.27$ Å, from the data of Cuthbertson and Cuthbertson (1910, 1932). Edwards (1958) measured $(N_0\alpha) = (0.12454\pm 0.00021)$ cm^3 mole^{-1} for liquid He^4 for $\lambda = 5462.27$ Å at 3.7° K and showed ($N_0\alpha$) was independent of temperature from 1.6° K to 4.2° K for liquid He^4 along the SVP curve. In what follows, we assume that this last value of ($N_0\alpha$) is correct at higher temperatures and pressures as well. Consequently, refractive index measurements may be considered as measurements of the vapor or liquid density ρ, through

$$\rho = (7.67523\pm0.0077)\,(n^2-1)\,(n^2+2)^{-1}, \tag{3.2}$$

and the isothermal compressibility, k_T, of the liquid, through

$$k_T = 6n(n^2-1)^{-1}(n^2+2)^{-1}(\partial n/\partial P)_T. \tag{3.3}$$

The numerical factor for equation (3.2), and its uncertainty, come from a combination of Kerr's (1957) absolute value of the density of liquid He^4 at 3.7° K and Edwards' (1958) absolute value of the refractive index of liquid He^4 at 3.7° K. Equation (3.3) follows by differentiation of equation (3.1), assuming that ($N_0\alpha$) is independent of temperature and pressure.

Once the density and isothermal compressibility are known, γ, the ratio of heat capacities, may be calculated for the liquid using

$$\gamma = \rho u_1^2 k_T \tag{3.4}$$

where u_1 is the velocity of first, or ordinary, sound.

Conventional theories of X-ray scattering by liquids (Zernicke and Prins 1927; and Brillouin 1922) predict that in the limit of zero-angle scattering, and not too near the critical temperature, the liquid structure factor is given by

$$\mathscr{L}_0 = N_0 k M^{-1} \rho k_T T \tag{3.5}$$

where N_0 is Avogadro's number, k is Boltzmann's constant, M is the molecular weight, ρ is the density, k_T is the isothermal compressibility, and T is the absolute temperature. Goldstein (1951*a*, *b*) has obtained the same result and has shown that equation (3.5) holds also for the coherent scattering of slow neutrons with vanishing momentum change, for atoms with zero spin nuclei. Furthermore, Goldstein and Sommers (1956) and Egelstaff and London (1957) have given expressions for various slow neutron scattering cross sections which involve the quantity $\mathscr{L}_0$ also.