ptical cell and in the helium
n absolute and differential
precision dial manometers.
nterference fringes could be
t the same time. The normal
was altered as follows. A
the Jamin telescope to give
only. Then a Bausch and
ned to the telescope, and a
ht box behind a slit in the
ead contains a beam splitter
ng eyepiece while 90% falls
from about a quarter of one
photomultiplier output was
1-second full-scale balancing
stem rarely exceeded about
fractive index.
cell were taken to be equal
. These temperatures were
e bath (on the 1958 scale of
a hydrostatic correction due
riment with a vapor pressure
rocedure correctly accounts
pth to within about $10^{-4}$° K,
cell were monitored with a
temperatures inside the cell
de the cell. Using the optical
o the conclusion that when
surface of the liquid in the
ures outside by up to 4 mdeg
at 3.5°, 23 medg at 3.0°, 20
w the λ-temperature. These
warmer liquid at the upper
only partially filled. Such a
r pressures. As we could not
y increasing the radiant heat
for this possible systematic
med, the temperatures were
bath with a Greiner Manostat
ds type LB1A needle valves,
he bottom of the bath by an
mperature of the cell from

lium vapor is related to the



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

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 $(0.1245\pm0.0005)$ cm$^3$ mole$^{-1}$ for $\lambda = 5462.27$ Å. He also calculated that, for helium gas at N.T.P., $(N_0\alpha)$ is $(0.1246\pm0.0002)$ 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 $\rho$, 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, $\gamma$, 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, $\rho$ 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.