D. THE MEASUREMENT OF f NUMBER

While the f number, the fraction of recoilless decays, is a very basic quantity in Mössbauer theory, its quantitative experimental evaluation, even at one atmosphere, is very difficult. The main purpose of such a measurement is to study the localized vibrational structure in the solid in the neighbourhood of the decaying atom. As we shall see, in transition metals in the first order this does not differ greatly from the vibrational structure of the host.

The extensive high pressure measurements involve ^{57}Co (^{57}Fe) as a dilute solute in copper, vanadium and titanium. These have respectively, the f.c.c., and b.c.c., and h.c.p. structures, although titanium undergoes a transition near 80 kb. We shall be concerned here only with the measurement of relative f's, that is the value of f relative to its value at one atmosphere and the same temperature (294°K). Figures 20 and 21 show plots of f/f_0 *versus* $\Delta V/V_0$ for copper and vanadium

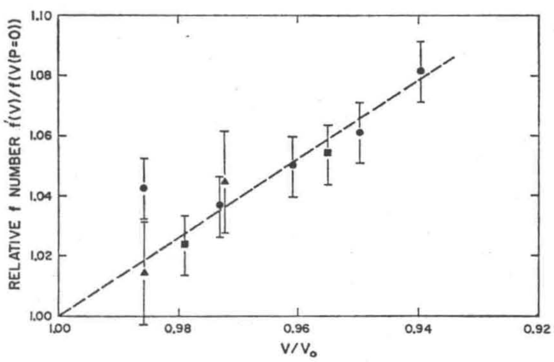

FIG. 20. f/f_0 *versus* $\Delta V/V_0$—copper.

from Moyzis and Drickamer (1968a). The titanium data are more scanty, but similar in nature. One sees that within the accuracy of the data the relationship is linear.

From eqn (3) it is convenient to write:

$$\frac{\partial \ln f}{\partial \ln V} = -\gamma Y \tag{22}$$

where $\gamma = -\dfrac{\partial \ln \theta}{\partial \ln V}$ is the Grüneisen constant,

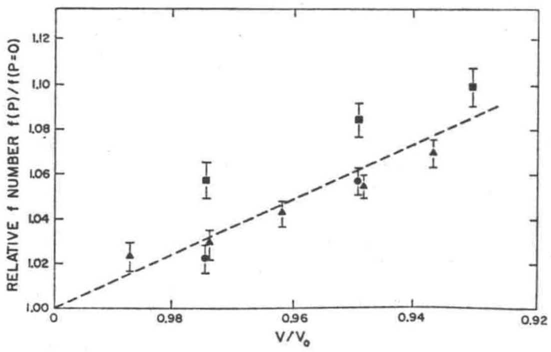

FIG. 21. f/f_0 *versus* $\Delta V/V_0$—vanadium.

and
$$Y = \frac{6E_r}{k\theta}\left[\frac{1}{4} - \frac{1}{e^{\theta/T}-1} + 3\left(\frac{T}{\theta}\right)^2 \int_0^{\theta/T} \frac{x\,dx}{e^x - 1}\right].$$

It should be noted that the dependence on $\omega(\langle\omega^{-2}\rangle)$ is the same as for X-ray scattering but differs from the specific heat which varies as $\langle\omega^{\theta}\rangle$.

The experimental results give:

$$\left.\frac{\partial \ln f}{\partial \ln V}\right|_{Cu} = -1{\cdot}283 \tag{23}$$

$$\left.\frac{\partial \ln f}{\partial \ln V}\right|_{V} = -1{\cdot}380 \tag{24}$$

$$\left.\frac{\partial \ln f}{\partial \ln V}\right|_{Ti} = -0{\cdot}843. \tag{25}$$

From these results it is possible to calculate a value for the characteristic temperature θ which can be corrected to apply to the host lattice by the relationship:

$$\theta_H = \left(\frac{m'}{m}\right)^{1/2} \theta_f \tag{26}$$

where $\theta_H = \theta$ of host, $\theta_f = \theta$ obtained from experiment, m, m' = mass of host and impurity atom.

Since the relationship of Figs 20 and 21 is linear, the above calculation can be assumed to apply at an average pressure of 50 kb. One