There is, then, no direct experimental information about the shape of the Fermi surface in the alkalis. What information we do have has been inferred from experiments on the transport properties. These transport properties depend on averages of scattering times and energy derivatives (electron velocities and effective masses) taken over the entire Fermi surface and yield useful information only if we have some model of the shape of the surface to start with. In the alkalis the expectation is that the Fermi surface is a warped sphere. The inferences that have been made agree that lithium shows severe warping and the Fermi surface may touch the zone boundary, that sodium has very little warping and that the warping probably increases as we go through the series potassium, rubidium and cesium.

D. The Fermi Surface as a Function of Pressure

With the availability of band calculations made at several values of lattice constant, theoretical predictions about the change in the shape of the Fermi surface with pressure can be made. The question arises as to possible experiments that will give information about the shape of the surface as a function of pressure. The high compressibilities of the alkali metals (Table 1-1) make possible significant changes of lattice constant in the pressure range available in the laboratory. As we have seen, the direct techniques for studying the Fermi surface such as de Haas-van Alphen or acoustic attenuation measurements have not yet been applied to the alkalis, in large part because of the difficulty of growing single crystals and handling the metals. Even if these difficulties are overcome, helium temperature pressure measurements are possible only over a small pressure range, since the pressure transmitting fluid freezes with application of relatively low pressures. Even with the use of solid hydrogen as the pressure transmitting medium the pressure is still relatively low, of the order of 5000 atmospheres, and shear stresses are present which may introduce non-hydrostatic strain and produce additional defects due to plastic deformation [49]. In order to take advantage of the pressure range available in the laboratory, measurements at either room or nitrogen temperatures are needed.

Since no direct means of determining the Fermi surface are available, the next best possibility is to measure some transport properties under pressure and interpret the results in terms of changes of the Fermi surface and of other parameters; preferably we would like to measure an effect that is sensitive to the shape of the Fermi surface alone.

The simplest transport property to measure is the conductivity. Unfortunately, this is quite insensitive to the shape of the Fermi surface and quite sensitive to the magnitude of the scattering time. This is best seen by noting the effect of warped surfaces of the form (I-4) on conductivity; Olson and Rodriguez give

$$\sigma = N e^2 \tau / m^* [1 - r^2 (0.190 + 1.85 t^2)] \qquad \text{(I-10)}$$

where N is the number of carriers/volume and τ is the isotropic scattering time. If we remember that t is of the order of unity and that $|r|$ is less than .1 (Table 1-1) we now see that warping of a closed Fermi surface will change the conductivity by less than 2 percent from the value for a spherical surface. Since the observed effect of pressure on the conductivity of alkalis is to produce changes of the order of 50 percent in 15,000 atmospheres, we can see that changes in τ and m^* far outweigh those in the shape of the surface.

On the other hand Eq. (I-5) for the magneto-resistance shows that this property is quite sensitive to the shape of the surface. Unfortunately, the magnitude of the magneto-resistance effect at room temperature is too small to be measured by ordinary techniques. Kapitza did manage to observe the magneto-resistance of sodium and lithium at room temperature by using pulsed fields of 300 kilogauss; he observed changes of resistance of less than 2 percent [50]. Since the effect goes as H^2 ordinary dc magnetic fields of 10 to 30 kilogauss would produce resistance changes in the range from .002 percent to .02 percent. Reducing the temperature to the liquid nitrogen range would not produce a significant improvement. Kapitza found a 15 percent effect in lithium at this temperature; this would become a .15 percent effect with a 30 kilogauss dc field. It is only in the helium temperature range that the magneto-resistance becomes large enough, of the order of 10 percent, so that a pressure experiment might be feasible; however, in this range the available pressure is limited, as we have mentioned.