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NUCLEAR SPIN RELAXATION IN SOLID He^3†

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The liquid states of both helium isotopes have been of particular interest due to their peculiar macroscopic properties which have been attributed to quantum effects. In solid He^3 the nuclear susceptibility departs from Curie's law,[1-3] below 0.2°K, indicating that some exchange interaction must be present in addition to the direct dipole-dipole interaction between atoms. Thus solid He^3 is also found to exhibit some such peculiar properties. A further distinctive property of solid He^3 is the α-β phase transition discovered by Grilly and Mills.[4] This transition has no analog in solid He^4, and its nature is not yet understood. Some relevant information contained in the original work of Grilly and Mills is that the volume change associated with the transition approaches zero at approximately 2°K. In the work to be described here, nuclear spin relaxation times were measured in solid He^3 such that they might yield additional information as to these properties.

Free-precession techniques were used to measure both the transverse and longitudinal relaxation times at 30.4 Mc/sec to an accuracy of roughly 10%. The measurements were made both as a function of pressure at constant temperature and as a function of temperature at constant volume. In order to allow pressure variation of the sample, a loop of resistance wire was placed inside of the capillary through which the He^3 entered the sample chamber. In this way, by passing a current pulse through the wire, the plug of solid He^3 which formed in the capillary could be melted momentarily and the solid in the sample chamber could come to pressure equilibrium with the vapor in the warmer part of the capillary.

Large discontinuities in both relaxation times were observed as the pressure was increased or decreased across the α-β phase boundary above approximately 2°K. Figure 1 shows the data at

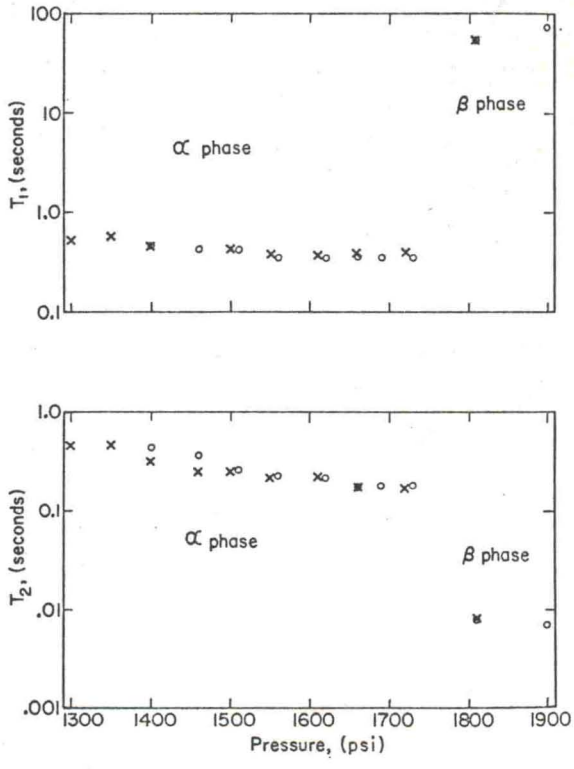

FIG. 1. Nuclear spin relaxation times in solid He^3 as a function of pressure at 2.2°K, indicating a discontinuity at the α-β phase boundary, discovered by Grilly and Mills (reference 4). Circles and crosses represent, respectively, data taken while increasing and decreasing the pressure.

2.2°K. The circles represent the data taken while increasing the pressure in steps and the crosses those taken while decreasing the pressure. At 1.37°K, however, the relaxation times displayed an exponential dependence on the pressure in the α phase and no discontinuity at the phase boundary. This may be seen in Fig. 2, where it may also be seen that T_1 passes through a minimum