shifted peak is about two seconds, nearly ten times longer than the relaxation time in the solid.

Some other experiments, also reported at the Boulder meeting, indicate there is still some question that the NMR results necessarily imply the occurrence of a phase transition in the liquid alone. William Halperin, R. A. Buhrman, Watt Webb and Richardson (Cornell) have measured the thermal relaxation time of approximately 95%-solid He^3 and found a sharp maximum at a pressure that corresponds to P_A. They have also measured the static magnetization of the liquid at fields of 0–100 gauss and found that it does not change at either B or B′. Although NMR and static magnetization studies do not measure the same quantity, they are connected (through the Kramers–Kronig relation) and the two sets of results may or may not be consistent: Further measurements of both kinds at comparable fields and frequencies must still be performed before a consistent interpretation can be attempted.

John Wheatley (University of California, La Jolla) reported some preliminary results that *do* suggest the occurrence of an anomalous transition in the liquid. Wheatley, Richard Johnson and Richard Webb cool He^3 by adiabatic demagnetization; because their experiments are not along the melting curve, they have only liquid present. They saw a reproducible pressure anomaly in a constant-volume cell at a temperature that corresponds to Cornell's point A. Wheatley, Johnson and Douglas Paulson have also verified the earlier Cornell pressurization measurements and have tentatively determined the temperature at points A and B with noise thermometry.

Theorists are aroused because the frequency-shift data suggest the existence of a magnetic field within the liquid, in other words, an ordered, anisotropic—and therefore possibly superfluid—liquid. When the Cornell group determined the splitting as a function of resonant frequency and pressure in applied fields from 30 to 850 gauss, they found that all their data fit a single function

$$\nu_l^2 - \nu_s^2 = (10.11p - 2.475p^2) \times 10^3 \mathrm{kHz}^2$$

The result is compatible with the existence of an effective internal magnetic field, orthogonal to the applied field; an internal field that is a function of temperature but not of the magnitude of the applied field. Extrapolation of the curve gives a maximum value of 31 gauss for this field.

Beginning in 1959,[3] a number of theorists in the USSR and in the US had calculated that, at low enough temperatures, He^3 should be a superfluid, although prediction of the exact transition temperature is so elusive that it has ranged from a few hundredths of a degree Kelvin down to 10^{-6}K. Because He^3 is composed of fermions, the hypothesized superfluid phase was thought to be similar to the Bardeen–Cooper–Schrieffer (BCS) pairing state responsible for the superconducting transition in metals. Another ingredient of the earlier theories was that in He^3 the relative orbital angular momentum of a pair must be in a state such that L is greater than zero, in contrast to superconductivity, where L equals zero.

Now that a phenomenon that could be superfluidity has appeared at a few millideg, several theorists have developed these ideas further. In particular, at the conference, Anthony Leggett, a theorist at the University of Sussex (UK) submitted a postdeadline paper in which he set down general relations, based on sum rules, which lead to the observed frequency-shift relationship. His calculations for odd L give good qualitative agreement with the A-liquid experiment.

At the same conference, Philip Anderson and Chandra Varma (Bell Labs) discussed work that they had in progress along similar lines and also suggested that the B transition could be understood by a further change in the angular-momentum symmetry of the pairs. More recently, they told us, they have done some further calculations in which L equals one, three or some other as yet indefinite odd value.

None of the theorists is claiming that superfluidity in He^3 has in fact been observed. The magnetic anomalies in the liquid might also be explained by some kind of standing spin density wave, both Anderson and Varma and Leggett point out. To determine whether or not a superfluid is present, studies of such properties as viscosity should be undertaken; such measurements are underway at a number of laboratories. But the theorists as well as the experimentalists note that the agreement between the observed He^3 properties and the calculated superfluid state is too good to ignore. —MSR

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Farewell to Utah's W-particle

Last year a group at the University of Utah said that the anomalous muon flux they had been observing in cosmic rays since 1966 was consistent with the observation of a W particle or intermediate vector boson (PHYSICS TODAY, November 1971, page 17). At the XVI Conference on High-Energy Physics (held at both the University of Chicago and the National Accelerator Laboratory) in September the group, Haven E. Bergeson, Gary Carlson, Jack Keuffel and James Morrison announced what Keuffel called "the obituary of the Utah effect." Keuffel told us, "Alas, no W's. It was fun while it lasted!"

One leading experimenter remarked to us that usually a group works right up to the wire to announce a new discovery at a conference. This is probably the only example of a group rushing to announce an antidiscovery. As of the end of August the Utah group was still unable to say how the results of a repetition of the experiment were coming out. But in a paper dated 10 September and submitted to the conference, the group withdrew its earlier claim.

In their earlier studies of the zenith-angle (θ) dependence of cosmic-ray muons, the Utah group reported an anomalous muon component that did not show the sec θ enhancement that was expected for muons from pion and kaon decay. As Keuffel put it, the data showed "too few skew mus." The group then interpreted this anomalous, isotropic component as suggesting the existence of a strongly produced massive parent particle with a strong branching ratio for muon decay. Now that they have repeated the experiment with improved Cerenkov counters and better methods of analysis, the group says the results are in satisfactory agreement with conventional pion and kaon parentage for muons.

Keuffel told us, "We were done in, as is so often the case, by several effects acting in concert: imprecise knowledge of the angular dependence of the old (pre-1971 renovation) Cerenkov detectors (which led us astray when using Utah data alone); small density variations of our rock, and especially an imprecise world-survey vertical muon intensity versus depth curve."

Once a conventional muon zenith angle variation is accepted, the Utah measurements at various inclined angles yield an improved vertical intensity versus depth curve. This curve, the Utah workers say, "can be understood at great depths only if there is a steepening of the primary cosmic-ray spectrum, a failure of scaling, or an anomalous absorption of muons operating in some combination." Keuffel remarks that with three other muon experiments now in progress at Utah, they will have a good chance at unravelling these effects. —GBL □