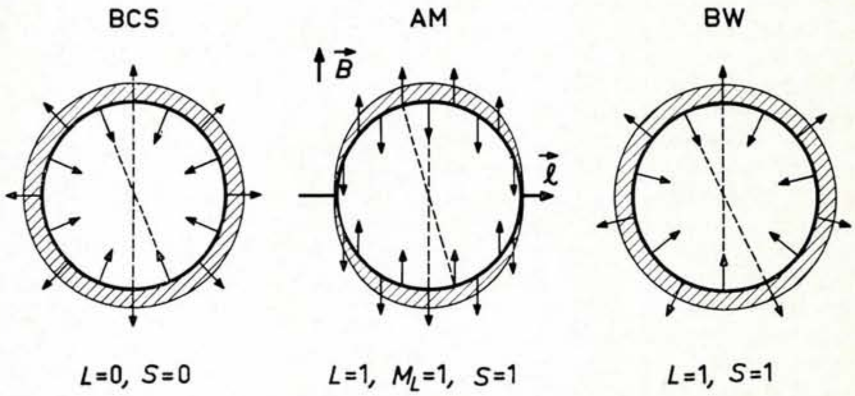

Fig. 4. An "over-simplified" picture of the BCS, AM, and BW ground states. Pairing occurs between two ^{3}He atoms on opposite sides of the Fermi-sphere; two pairs are indicated in each case with a dashed line. In the AM- and BW-states the spins (shown by arrows) of paired atoms are parallel to each other, in contrast with the antiparallel arrangement of the BCS-state. Shaded areas illustrate the energy gap Δ. In the AM-state the anisotropic Δ is symmetric about the ℓ- axis.

creases rapidly in the B-liquid. The height of the viscometer signal at the lowest experimental temperature, probably near 1.0 mK, is almost four times the amplitude at 10 mK and is increasing with decreasing temperature very quickly indeed. Two hysteresis loops, associated with the transition between the A- and B-liquids, are also clearly seen. These measurements provided the first dramatic indication of superfluidity in ^{3}He.

The experiments have recently been repeated with improved techniques[21]. The new data show that resistive flow of liquid ^{3}He in the A- and B-phases is accompanied by a flow of zero viscosity; this proves superfluidity of ^{3}He. In terms of the two-fluid model, damping of a vibrating string is caused by the normal fraction of the liquid; the superfluid component manifests itself only through the hydrodynamic mass of the wire. By measuring accurately the amplitude or the width and the frequency shift of the resonance curve it is possible to calculate separately the viscosity η_n and the density of the normal component.

The results show that as liquid ^{3}He cools through the FA-transition, η_n decreases rapidly, within 0.3 mK, to about 25 % of its value in the Fermi-liquid region and then stays essentially constant. At the AB-boundary η_n drops an additional 5 % and then starts to increase as the temperature is further reduced. The viscosity of liquid ^{3}He thus behaves qualitatively in a manner familiar from experiments on liquid ^{4}He below 2.2 K.

According to Alvesalo et al.[21] the normal density decreases relatively slowly with temperature in the A-phase, approximately as T/T_{AF}; this is in fair agreement with the fourth sound measurements[18], [19] discussed earlier. At the AB-boundary, however, ρ_n drops abruptly from about 60 % of the bulk liquid density to 25 % of ρ and then decreases rapidly upon further cooling. Below 1.3 mK, ρ_n is less than 1% of ρ. The rapid variation of ρ_n as a function of temperature in the B-phase is in disagreement with the data of Kojima et al.[18] and of Yanof and Reppy[19]; these authors observed no appreciable change in the temperature dependence of ρ_s/ρ at the AB-boundary. The discrepancy may indicate that the properties of superfluid ^{3}He are changed when the liquid is confined inside a porous medium necessary for the observation of fourth sound[15].

The discovery of superfluidity in liquid ^{3}He did not come unexpectedly; it had been foreseen by several individuals ever since the BCS-theory of superconductivity was published in 1957. However, predictions for the transition temperature varied many orders of magnitude. Superfluidity in ^{3}He is more closely related to superconductivity in metals than to superfluidity in ^{4}He; the first two phenomena are characterized by pairing of Fermi-Dirac particles whereas superfluidity in ^{4}He is related to Bose-Einstein condensation.

According to the BCS-theory of superconductivity, two electrons on opposite sides of the Fermi-surface and of opposite spins feel a slight attraction. If this interaction is not too weak the electrons form a Cooper pair and fall into the superconducting ground state. The attractive potential can be described as a slight deformation of the crystalline lattice by one of the electrons which is sensed by its partner. The BCS-ground state (cf. Fig. 4), separated from the single-electron excited states by an energy