Hakonen, P. J.; Krusius, M.; Salomaa, M. M.; Simola, J. T.

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Comment on "Nucleation of ^{3}He-*B* from the *A* Phase: A Cosmic-Ray Effect?"

In an interesting Letter, Leggett[1] suggests that the nucleation of ^{3}He-*B* from the metastable *A* phase is a consequence of the passage of a cosmic ray through the sample cell. Here we present new experimental data obtained with a rotating cryostat in NMR experiments[2] on ^{3}He. Figure 1(a) shows our data, taken on the $A \rightarrow B$ transition in magnetic fields of 28.4 and 56.9 mT; no field dependence was found between these values. We find that supercooling of the *A* phase into the *B* phase is substantial, and there appears to be a threshold temperature ("catastrophe line") $T^*_{AB}(p) \ll T_{AB}(p)$, where the metastable *A* phase first changes into ^{3}He-*B*.

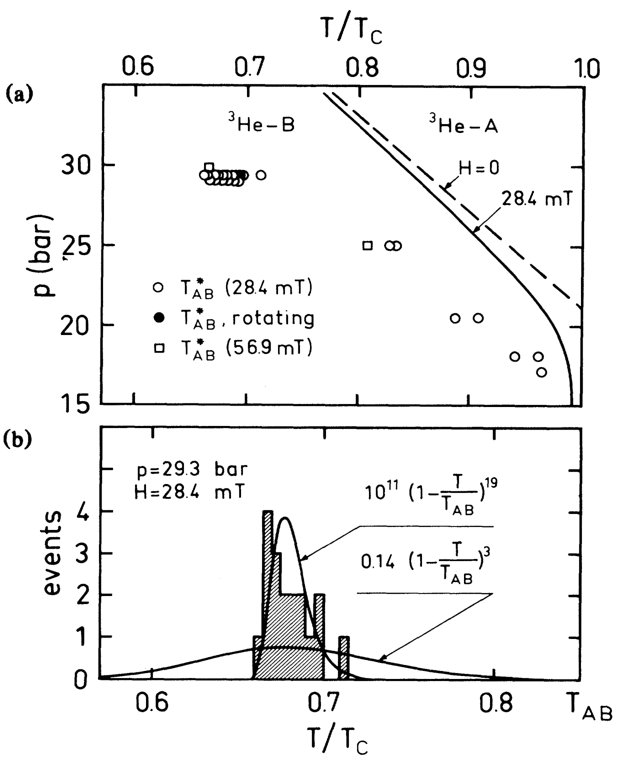

FIG. 1. (a) Supercooling of the *A* phase into the *B* phase as a function of pressure. (b) Observed nucleation events (histogram) at 29.3 bars are inconsistent with the probability distribution of Ref. 1 with $P(T) \propto (1-T/T_{AB})^3$. Clearly, only a much more sharply peaked probability at a lower temperature than suggested in Ref. 1 can describe the data; an exponential law for the activation process might be appropriate.

We want to emphasize that in our ^{3}He cell the $A \rightarrow B$ transition could *only* be observed *during cooling*, never on warmup. The cooling rate varied between 5 and 29 μK/min, but no clear dependence of *B*-phase nucleation on the cooling rate could be established. When the temperature was stable, the *A* phase was found to persist, and no $A \rightarrow B$ transition was ever observed in this case. For example, at $p = 29.3$ bars (with $T_{AB} = 0.85T_c$) and 28.4 mT, the *A* liquid was cooled as low as $T_{\min} = 0.67T_c$, and was maintained below $0.7T_c$ for 2 h; in this run the metastable *A* phase persisted a total of 8 h, never nucleating the *B* phase. The temperatures in Fig. 1 are upper-bound estimates for T^*_{AB}. They are determined from NMR susceptibility measurements on platinum powder immersed in the ^{3}He. A comparison with the *A*-phase NMR frequency-shift measurement shows that on cooling, the platinum temperature lags behind, at a cooling rate of 20–30 μK/min by $\lesssim 0.02T/T_c$. Even lower liquid temperatures exist in the heat exchanger between the ^{3}He sample and the refrigerator.

Figure 1(b) represents the data points at 29.3 bars as a histogram and compares them with a fitted distribution of nucleation probability. We conclude that experimentally the nucleation mechanism appears to be active only in a narrow temperature interval near the "catastrophe line" well below the thermodynamic $A \rightarrow B$ transition. An interesting point to note is that on cooling through the $A \rightarrow B$ transition during rotation, the *A* phase stayed supercooled as long as in the stationary liquid. This is further (indirect) evidence in support of the conclusion[3] that continuous vortices are induced by rotation in a bulk liquid sample of ^{3}He-*A*.

P. J. Hakonen
M. Krusius
M. M. Salomaa
J. T. Simola
Low Temperature Laboratory
Helsinki University of Technology
SF-02150 Espoo 15, Finland

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