**Phase Separation in 3He-4He Solid Solutions**

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**Introduction**

 Phase separation in 3He-4He mixtures represents an especially clear example of a firstorder phase transition with a conserved order parameter. The quantum nature of the diffusion sets “fast” time scales (~ hours) for the phase separation dynamics (in contrast to that for metal alloys), enabling measurements on experimental time scales. 3He-4He mixtures have very few defects, and substantial supercooling is possible. The separation is well understood [1-3] for high concentrations but has not been tested for very low concentrations, i.e. tens of ppm where the transitions are especially sensitive to asymmetries in the mixing interaction and free energy differences of the hcp & bcc phases.

**Experimental**

 The samples were prepared with carefully controlled 3He concentrations and grown slowly in an NMR cell under pressures such that the homogeneous mixtures are solid solutions but for which the 3He separates as a liquid phase. The sample was thermally linked to a dilution refrigerator via sintered silver. Pulsed NMR techniques were used to monitor the NMR amplitude that undergoes a sharp drop at the separation because of the reduced susceptibility of the Fermi liquid.

**Results and Discussion**

 The phase separation temperatures were found to be in excellent agreement with the predictions of regular solution theory given by equation (1).

$$T\_{ps}= \frac{0.76}{k\_{B}}\frac{\left(1-2x\_{3}\right)+A\_{3}}{\left[ln\frac{1}{x\_{3}}-1\right]}$$

 [1]

**Fig.1** Variation of the phase separation

temperatures with 3He concentrations for solid solutions of 3He in 4He.

*A3* is a correction that accounts for the different free energies of the different lattice structures of pure 3He and pure 4He.

**Conclusions**

 The observed phase separation temperatures for solid 3He-4He mixtures are in excellent agreement with regular solution theory provided one accounts for the difference in free energy of the bcc 3He and hcp 4He structures.

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