Neutron Reflection from the Surface of a Liquid ^{3}He–^{4}He mixture

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We have investigated the surface properties of liquid ^{3}He–^{4}He mixtures by small-angle neutron reflection for temperatures in the range $80 < T < 2200$ mK. Comparable results were obtained for the two samples studied: commercial helium with ~ 0.3 ppm of ^{3}He, and stronger mixture containing 0.5% ^{3}He. In each case, we compare the neutron intensity for different temperatures, and fit a model that describes the collected data. We find that the data are consistent with there being a diffusive ^{3}He layer of a few hundred Å thickness on the bulk ^{4}He liquid surface. Even at high temperatures ($\sim$2K) there is an increased concentration of ^{3}He atoms near the surface. The distribution of ^{3}He with respect to distance from the surface is not strongly temperature-dependent. At low temperatures the neutron absorption increases significantly, which might be an indication of the formation of Andreev states. The fact that the shapes of the reflectivity curves do not change very much with temperature, suggests that the additional ^{3}He layer is very thin $\sim$ 10Å, which agrees well with the concept of Andreev states. We comment that neutron reflectometry has opened up new opportunities in the study of surfaces and interfaces of quantum fluids and solids.