Odd-Frequency Cooper Pairs near the Surfaces of Superfluid ^{3}He-B

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There can in general coexist even-frequency and odd-frequency Cooper pairs near the surfaces of superconductors and superfluids owing to broken translational symmetry. We report our recent theoretical study on the odd-frequency pair amplitudes near the surfaces of superfluid ^{3}He-B. To calculate the odd-frequency pair amplitudes, we have applied the quasiclassical Green's function theory taking into account the effect of diffusive scattering at the surface. There appear odd-frequency Cooper pairs with a variety of orbital symmetries even in the diffusive scattering limit. The energy dependence of the odd-frequency pair amplitude below the gap is quite similar to the local density of states near the surface. In the zero-energy limit, in particular, the two coincide exactly with each other. As is well known, the Andreev surface bound states are formed in the B phase of superfluid ^{3}He and yield a finite zero-energy value of the surface density of states. It has been confirmed by the measurements[1] of transverse acoustic impedance that the surface density of states in superfluid ^{3}He-B has such a finite zero-energy density of states. This suggests strongly that the odd-frequency Cooper pairs in fact exist near the surfaces of superfluid ^{3}He-B.

[1]S. Murakawa *et al.*, Phys. Rev. Lett. **103**, 155301 (2009).