WAVES ON QUANTUM SURFACES

I. Todoshchenko, A. Savin, M. Haataja and P. Hakonen

Low Temperature Laboratory, Department of Applied Physics, Aalto University, P.O.Box 15100, FIN-00076 Aalto, Finland
email: todo@ltl.tkk.fi

An interface between two media with distinct symmetry forms a topologically stable system. This allows for existence of exotic particles, for instance Majorana fermion (a particle which is its own anti-particle) [1] or anyon (particle which is neither boson nor fermion). It is also possible that the Universe is in fact an interface between media of larger dimensionality, which makes the investigation of surface excitations very interesting and intriguing.

Among various kinds of surfaces, the most interesting are interfaces between different phases of helium. They manifest superfluidity of at least three different types and, in their solid phases, point defects are delocalized. The most effective way to explore the excitations living on helium interface is to study surface resonances. In addition to usual capillary waves, helium supports also phase waves, like melting-freezing waves (see Fig.1) on the surface between liquid and solid [2]. We demonstrate for the first time the crystallization waves on the surface between the superfluid and solid phases of helium-3, which appear only well below 1 mK. The experiment was carried out on dry demagnetization cryostat aimed for sub-millikelvin helium experiments [3].

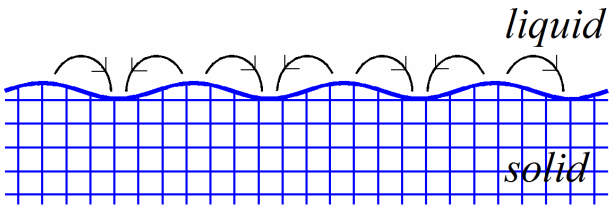

Fig. 1. Melting-freezing wave on the surface between fluid and solid phases.

We also discuss the possibility of a phase wave on the interface between two different superfluid phases of helium-3. This wave does not have usual inertial mass and its inertia is provided by spin supercurrents. This wave is unique as propagating on the boundary between two topologically different quantum media and it provides quite likely the best tool for exploring exotic surface particles at this interface.

[1] F. Wilczek, Nature Phys. **5**, 614 (2009).
[2] A.F. Andreev, A.Ya. Parshin, Sov. Phys. JETP **48**, 733 (1978)
[3] I. Todoshchenko, J.-P. Kaikkonen, R. Blaauwgeers, P.J. Hakonen, and A. Savin, A, Review of Scientific Instruments **85**, 085106 (2014)