The mechanism of Nanowire Production in Quantized Vortices of Superfluid Helium

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In 2009 the quantized vortices were proposed to be used as the universal 1D template for the growth of thin filaments by the condensation of impurities, in particular metals, embedded into HeII [1]. Starting from 2010 the nanowires of many metals and their alloys were grown in this way, the atoms and small clusters were created in HeII by laser ablation of submersed metallic targets ([2] and references there).

Recently the nanowires were detected as well under metal atoms capture into the cold liquid helium submicron droplets ([3] and references there). The quantized vortices were no doubt the templates inducing the growth of condensation product in one direction there too.

The diameters of the nanowires, their structure and morphology of nanowebs formed by condensation of metals in superfluid bulk helium, have been studied in sufficient detail. The electrical conductivities of nanowebs and individual nanowires were measured in a wide temperature range for normal and superconducting metals, the mechanism of nanowire nucleation and growth in the core of quantized vortices, explaining their structure and thickness, has been proposed and justified.

Nanowires formed in cold helium droplets are still described only qualitatively. Thus the question still exists whether these nanowires are similar to that produced by laser ablation in bulk HeII or not. Despite the reasons for nanowire production in these systems are very close, the answer to this question is not obvious. Firstly, the temperature in helium droplets (0.37K) is much lower than in that in the bulk experiments (1.5 - 2.0 K). On the one hand, it facilitates the capture of atoms into the core of vortex, but on the other hand hinders the motion of trapped atoms and clusters along the vortex core. Secondly, no interaction of vortices with each other exists in the droplets.

This problem will be analyzed in the present report by using the extensive data from experiments performed in the bulk superfluid helium.

References:

1. Gordon E.B., Okuda Y.// Low Temp. Phys. -**2009**, -**35**(3), 209.
2. Eugene B. Gordon, Alexander V. Karabulin, Vladimir I. Matyushenko, Vyacheslav D. Sizov and Igor I. Khodos. // Phys. Chem. Chem. Phys .**- 2014**, **- 16** (46), 25229.
3. Philipp Thaler, Alexander Volk, Florian Lackner, Johannes Steurer, Daniel Knez, Werner Grogger, Ferdinand Hofer, and Wolfgang E. Ernst // Physical Review B – **2014**, **90**, 155442.