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Non-isothermal physico-chemical processes in superfluid helium

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Liquid helium cooled below T=2.17 K, namely superfluid helium, is homogeneous structureless liquid with ultrahigh thermal conductivity and it seemingly represents no interest as a matrix for chemical reactions. Indeed the reaction kinetics should be diffusion-controlled, and every collision at such low T would lead to instantaneous coalescence into loose fractal structure. These trivial arguments, fortunately, turned out to be fundamentally wrong. The point is that practically any perturbation of superfluid helium leads to the nucleation of quantized vortices, 1D (diameter ≈ 1Å, length≈ 1cm) excitations, which attract by Bernoulli forces any guest particle to vortex core. The captured particles freely moving towards each other along the core have much more probability to collide than in bulk liquid. As a result, the coagulation in superfluid helium proceeds mainly in vortices and leads to the formation of long thin nanowires, not spheres as usual. The ultrafast heat transfer in superfluid helium is associated with the laminar flow of its normal component. However this flow is turbulized already at modest values of the heat flux density equal to several W/cm^2. In order to avoid self-fusion under two nanoclusters merging, the heat fluxes by orders of magnitude larger are necessary. As a result, liquid helium evaporates around the coagulation product forming a gas bubble of low pressure, which prevents the heat leakage. Thus, the product heats up to thousands of Kelvin and then melts, acquiring a spherical shape and a dense structure due to surface tension. And only provided the clusters grow up to certain size they become to stick together into nanowires. By using these effects we: (i) created the universal method for production of thin nanowires with perfect shape and structure, and (ii) realized in the laboratory the imitation of interstellar dust growth in the space.

Recent Publications:

1. Gordon E B et al. (2017) Coagulation of metals in superfluid and normal liquid helium. J. Phys. Chem. A. 121(48):9185-9190.
2. Krasnokutski S A et al. (2017) Low-temperature condensation of carbon. The Astrophysical Journal. 847:89.
3. Gordon E B et al. (2017) Non-isothermal physical and chemical processes in superfluid helium. Low Temp. Phys. 43:1086-1093.
4. Gordon E B et al. (2015) Production of ultrathin nanowires from refractory metals (Nb, Re, W, Mo) by laser ablation in superfluid helium. Laser Physics Letters. 12:096002.
5. Gordon E B et al. (2015) Experimental study of thermal stability of thin nanowires. Journal of Physical Chemistry A. 119(11):2490-2501.

Biography

Eugene B Gordon pursued his PhD in 1970 from Moscow University for Physics and Technology (MUPT) and Doctor of Science Degree in 1981 from the Institute of Problems of Chemical Physics (IPCP) of the Russian Academy of Sciences, Russia. He is currently the Principal Scientist of IPCP and Professor of Chemical Physics in MUPT. He has published more than 180 papers in reputed journals. He is the Member of All-Russia Supreme Qualification Committee; Member of Dissertation Councils in the IPCP and in Joint Institute of High Temperatures. He has his expertise in chemical kinetics, spectroscopy, chemical physics at low temperature.

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