Retention of Liquid Helium Films by an Electric Field in Ultracold Neutron Traps

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A film of liquid helium on the surface of material traps for ultracold neutrons protects the neutrons from being absorbed by the trap walls [1–3]. The main problem with this idea is that the thickness of the ^{4}He film on the side walls is too thin. This problem is solved by applying a potential difference between the side wall of the ultracold neutron trap and the electrode, which leads to an enhancement of the electric field near the roughness of the wall. By using surface roughness and an electrostatic field, a helium film of sufficient thickness can be held over the entire height of the trap. We calculated the field distribution near the tip of such wall roughness of the trap and estimated of the influence of this field on the retention of helium.

We investigated how the transition from two-dimensional artificial roughness of the equipotential surface in the form of periodically arranged triangular grooves to three-dimensional roughness in the form of periodically arranged square pyramids enhances the electric field near the pyramid vertices. Two-dimensional roughness corresponds to diffraction gratings, the production of which has long been developed and which are available for purchase. Three-dimensional roughness in the form of quadrangular pyramids is not much more complicated to produce, but still requires costs, so the transition from two-dimensional to three-dimensional wall roughness is justified only if the gain is noticeable. Our calculations showed that the gain from such a transition is significant, only if the angle of the pyramid vertex is small enough and the distance to the vertex is not too large. Otherwise, roughness in the form of a diffraction grating is almost as effective as the more complex three-dimensional roughness in the form of periodically arranged pyramids.

The proposed full coverage of the walls of ultracold neutron traps with liquid ^{4}He can lead to the emergence of a new generation of traps for ultracold neutrons with a very long storage time. This can significantly improve the accuracy of neutron lifetime measurements and other experiments with ultracold neutrons.

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2. P.D. Grigoriev, A.M. Dyugaev, *Superfluid helium film may greatly increase the storage time of ultracold neutrons in material traps*, Phys. Rev. C **104**, 055501 (2021).
3. P.D. Grigoriev, A.M. Dyugaev, T.I. Mogilyuk, A.D. Grigoriev, *On the Possibility of a Significant Increase in the Storage Time of Ultracold Neutrons in Traps Coated with a Liquid Helium Film*, JETP Letters, **114**, 493 (2021).