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The third sound as an electric field generator

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It is predicted that oscillations of temperature during propagation of third sound in a thin superfluid film cause appearance of an alternating electric field in the surrounding space, i.e. the third sound acts as a generator of the electric field [1].
As known, the helium atoms have no dipole, quadrupole and other multipole moments. The situation changes in the vicinity of the wall. Interaction of helium with the container walls leads to the emergence of a nonzero average dipole moment of the helium atoms directed along the normal to the wall. This leads to polarization of the film. Oscillations of its surface are accompanied by polarization oscillations, which cause the appearance of the electric fields over the film. Specificity of a superfluid film is associated with the ability to cause oscillations of the film surface by periodically heating the film boundary. As a result, due to the anomalously large thermomechanical effect, a small temperature difference ΔT leads to large fluctuations in film height and electrical potential $\Delta\varphi$. It turns out that the differential thermal e.m.f. $\Delta\varphi/\Delta T$ exceeds its value for typical metals. The predicted effect can be considered as an electrical analogue of the fountain effect.
Using the method of I.E. Dzyaloshinskii, the average electric field over the system "atom-solid" was calculated. It is shown that this electrical field is equivalent to the field of the dipole moment of the atom (induced by substrate) and its image. The polarization of the system, associated with its inhomogeneity (analogue of the flexoelectric effect), was also considered. It has been established that the flexoelectric effect leads only to a small renormalization of the dipole moment induced by the substrate. The equations describing the propagation of the third sound through the film have been solved. The effects of evaporation and condensation of helium atoms were taken into account. The relationship between oscillating parts of the height and temperature of the film was found for the low-temperature and high-temperature regions. For helium film covering a hollow cylinder on the outside or inside, an analytical expression for the electric field in space has been found. The coefficient of proportionality between the electric potential and the oscillating part of the film temperature (differential thermal e.m.f) was calculated.
[1] S. I. Shevchenko and A. M. Konstantinov, J. Low Temp. Phys. (2018).

Primary authors: Prof. SHEVCHENKO, Sergey (B.Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine); KONSTANTINOV, Aleksandr (B.Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine)

Presenter: KONSTANTINOV, Aleksandr (B.Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine)

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