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The charge and the dipole moment of quantized vortex structures in superfluid systems

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The problem of the electric fields created outside a superfluid liquid when quantum vortices and vortex rings appear inside the system is solved. It is shown that in the presence of a magnetic field a quantum vortex line acquires a linear charge density. The value of the charge density depends on the angle between the circulation vector and the magnetic field. It was found that a charge is associated with a rectilinear vortex filament, and a dipole moment is associated with a vortex ring. It was found that the key role while observing of electric fields outside the system is played by the shape of the surface that bounds the superfluid system. It was established that the polarization associated with the velocity field of the vortex ring does not cause the appearance of an electric field outside an infinite cylindrical capillary with a circular cross section in the case when the capillary axis coincides with the ring axis. If the system does not have such a high symmetry and the axis of the ring does not coincide with the axis of the capillary, the electric field outside the system is nonzero. The considered vortex structures can be generated by flows and can be associated with the transition of the system to a quantum turbulent state. For a laminar counterflow state of a superfluid system in a cylindrical circular capillary the electric potential outside the system is identically equal to zero [1,2]. Therefore, the predicted magneto-electric properties of quantum vortex structures can serve as a basis for creating a sensitive quantum turbulent state detector for superfluid systems.

[1] S. I. Shevchenko and A. M. Konstantinov, JETP Letters, 109, 790 (2019).
[2] S. I. Shevchenko and A. M. Konstantinov, Low Temp. Phys. 46, 48 (2020).

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