Vortex Interactions in Superfluid ^{4}He in the Zero Temperature Limit

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We have investigated the interactions of quantized vortex rings with each other and with vortex tangles in superfluid helium below 0.5 K. Seed charged rings, of radii in the range $R_0 \approx 0.5 \pm 0.2\,\mu$m, were injected into the drift space where an applied electric field was used to increase the ring radii R. At high injected densities and large radii R most rings reconnect leaving behind a slow moving charged tangle, so only a density $n_\mathrm{c} \approx 5 \times 10^{-4} R^{-3}$ of rings keeps propagating forward – the measured value of n_c being independent of the initial ring density, duration of injection and applied field. Numerical simulations of 10^4 forward-moving charged rings, such that when two rings collide geometrically their radii are changed so that the total impulse is conserved but a random amount of energy is dissipated, reproduce key features of the observed current transients and yield a comparable critical density of $n_\mathrm{c} \sim 10^{-3} R^{-3}$.
When charged rings are injected into an existing vortex tangle of density $L \sim 10^4$ cm^{-2} that fills the whole container, a fraction of charge travels through the tangle with the drift velocity $\sim 20\,\mathrm{cm\,s^{-1}}$. Such fast transport of charge does not occur at the slightly higher temperature of 0.7 K. These observations can be explained if, at $T \leq 0.5$ K, vortex reconnections within the tangle lead to the re-emission of very small charged rings ($R < 0.1\,\mu$m) – that initially propagate rapidly in the direction of field until growing and reconnecting with the tangle. We are thus getting an insight into the dynamics of vortex lines on small length scales in the zero-temperature limit – when frequent self-reconnections are expected to occur.