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Symmetry breaking in weak- and strong- coupled ring-shaped superflows of Bose–Einstein condensates

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One of the most remarkable manifestations of quantum properties of superconductors and superfluids is formation of Josephson vortices (JVs), alias fluxons, in long Josephson junctions.
In this work, we studied weak- and strong-coupled systems of two parallel superfluid rings with different angular momenta. Atomic Bose-Einstein condensates loaded in a dual-ring trap (two rings separated by a horizontal potential barrier) suggest a possibility to consider the tunneling dynamics.
Our research corresponds with investigation of tunneling influence on dynamics of coupled ring-shaped systems of superflows by numerical simulations in framework of weakly dissipative mean-field model.
In case of weak-coupling, symmetry breaking suggests Josephson vortex nucleation between the superflows with different angular momenta in low density area.
In case of strong-coupling (when the barrier is gradually eliminated), we observed the following situation: the JVs accumulate more and more energy and there is substantially 3D dynamics of vortices. We describe dynamics of counter-rotating superflows with and without axial symmetry breaking. It is demonstrated that the population imbalance between the merging flows and the breaking of the underlying rotational symmetry can drive the double-ring system to final states with different angular momenta.

Primary authors: Dr YAKIMENKO, Alexander (Department of Physics, Taras Shevchenko National University of Kyiv); Dr MALOMED, Boris (Department of Physical Electronics, Faculty of Engineering, and Center for Light-Matter Interaction, Tel Aviv University); Mr YATSUTA, Igor (Department of Physics, Taras Shevchenko National University of Kyiv); Mr OLIINYK, Artem (Department of Physics, Taras Shevchenko National University of Kyiv)

Presenter: Mr OLIINYK, Artem (Department of Physics, Taras Shevchenko National University of Kyiv)

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