New study explains interaction between quantized vortices and normal fluids

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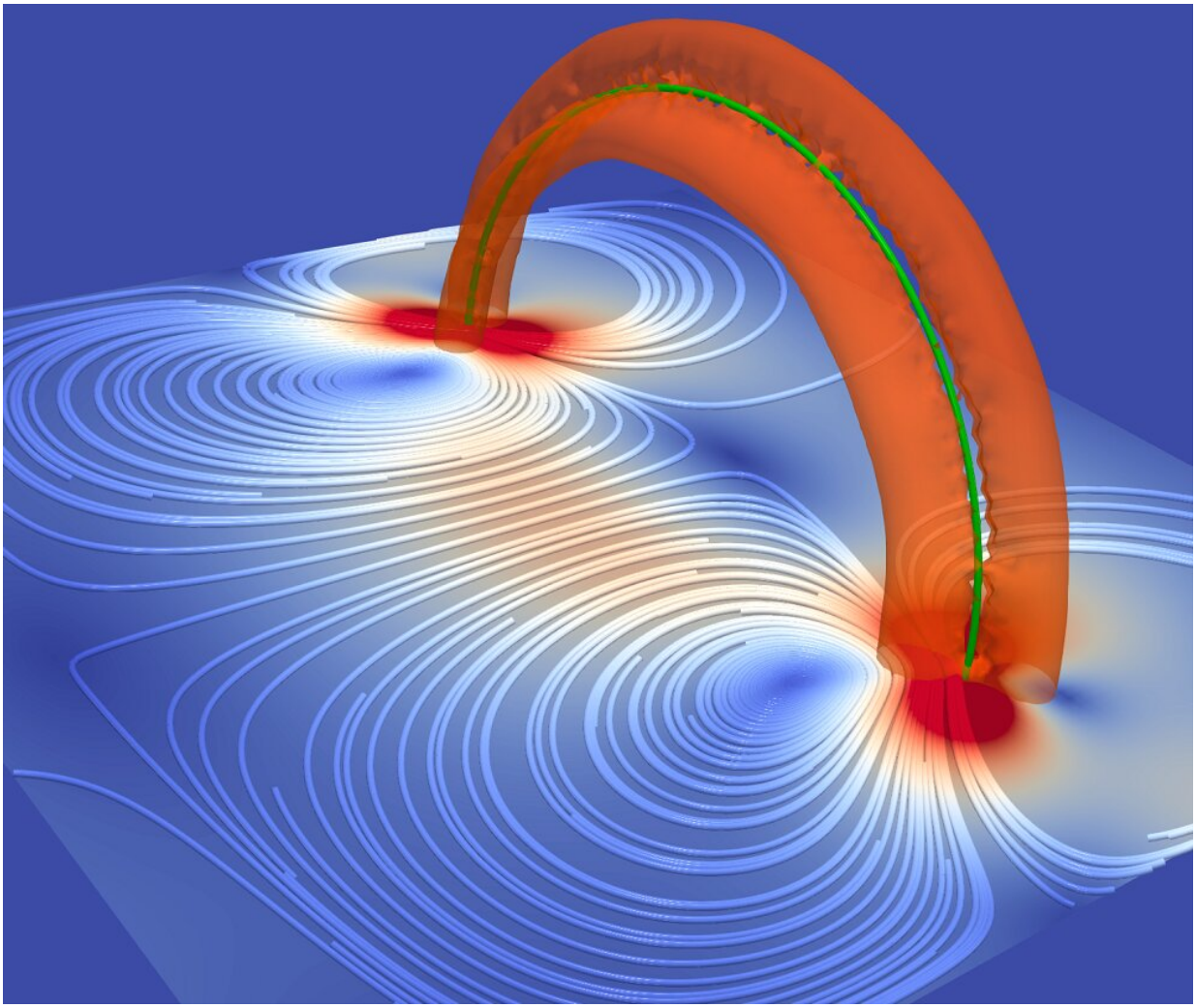

Visualization of quantized vortex ring above the plane (green curve), normal-fluid vortex rings (reddish half circles). Credit: Makoto Tsubota, OMU

Osaka Metropolitan University scientists investigated numerically the interaction between a quantized vortex and a normal fluid. Based on the experimental results, researchers decided the most consistent of several theoretical models. They found that a model that accounts for changes in the normal fluid and incorporates more theoretically accurate mutual friction is the most compatible with the experimental results.

Liquid helium-4, which is in a superfluid state at cryogenic temperatures close to absolute zero (-273°C), has a special vortex called a quantized vortex that originates from quantum mechanical effects.

When the temperature is relatively high, the normal fluid exists simultaneously in the superfluid helium, and when the quantized vortex is in motion, mutual friction occurs between it and the normal fluid. However, it is difficult to explain precisely how a quantized vortex interacts with a normal fluid in motion. Although several theoretical models have been proposed, it has not been clear which model is correct.

A research group led by Professor Makoto Tsubota and Specially Appointed Assistant Professor Satoshi Yui, from the Graduate School of Science and the Nambu Yoichiro Institute of Theoretical and Experimental Physics, Osaka Metropolitan University respectively in cooperation with their colleagues from Florida State University and Keio University, investigated numerically the interaction between a quantized vortex and a normal fluid.

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"The subject of this study, the interaction between a quantized vortex

and a normal fluid, has been a great mystery since I began my research in this field 40 years ago," stated Professor Tsubota. "Computational advances have made it possible to handle this problem, and the brilliant visualization experiment by our collaborators at Florida State University has led to a breakthrough. As is often the case in science, subsequent developments in technology have made it possible to elucidate, and this study is a good example of this."

Their findings were published in *Nature Communications*.

More information: Yuan Tang et al, Imaging quantized vortex rings in superfluid helium to evaluate quantum dissipation, *Nature Communications* (2023). DOI: 10.1038/s41467-023-38787-w

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