Variable Density Vortex Ring Dynamics in Sharply Stratified Ambient Fluids

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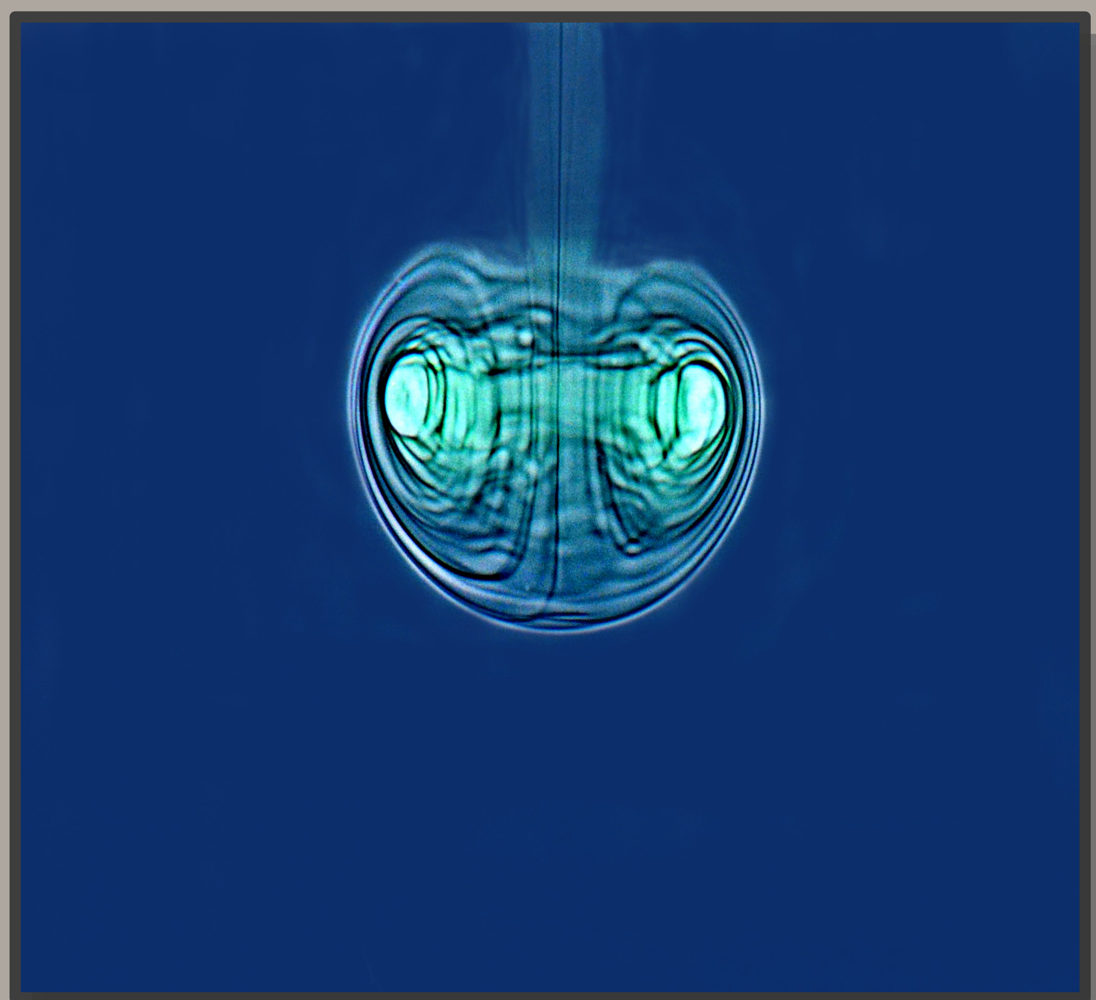

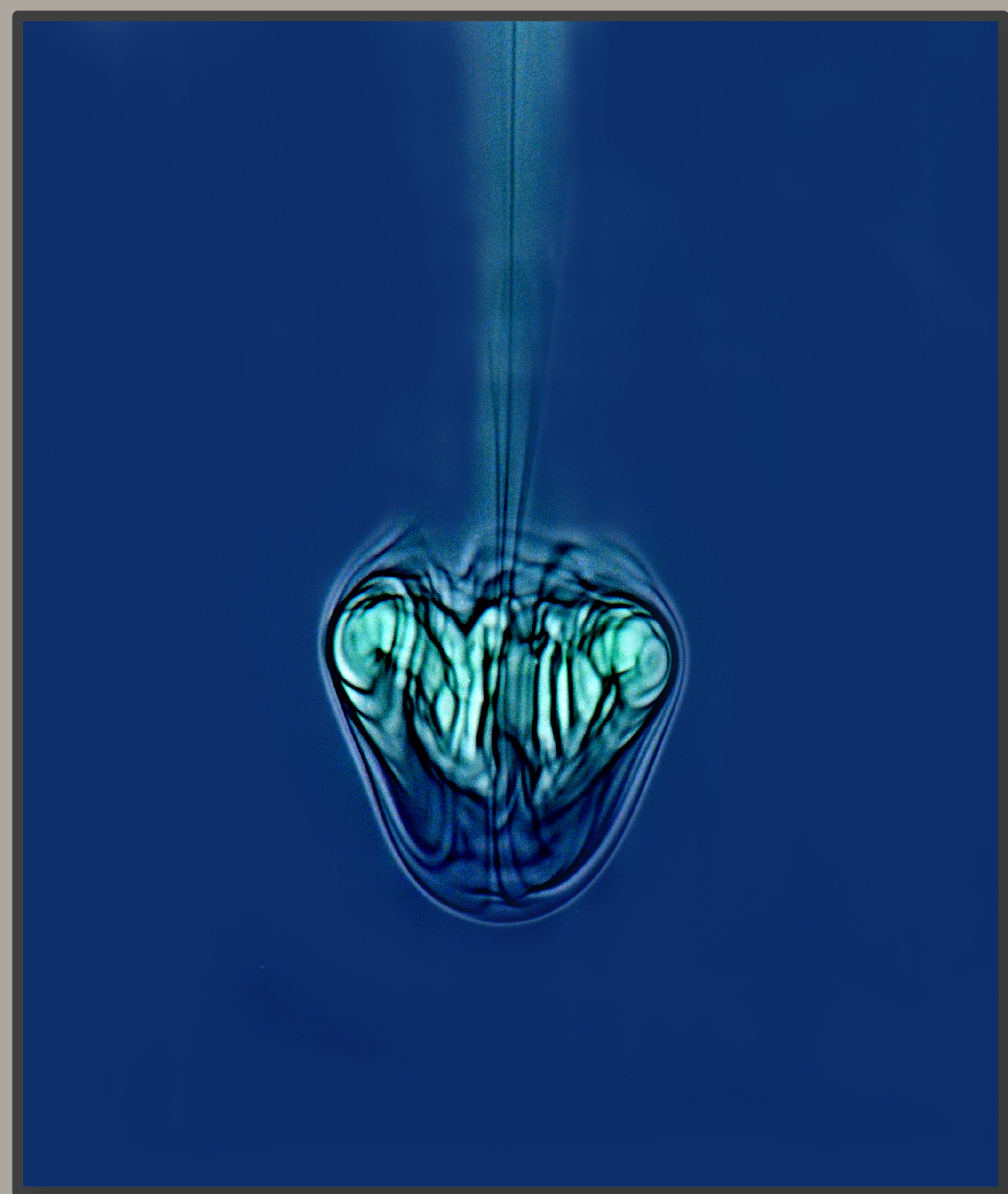

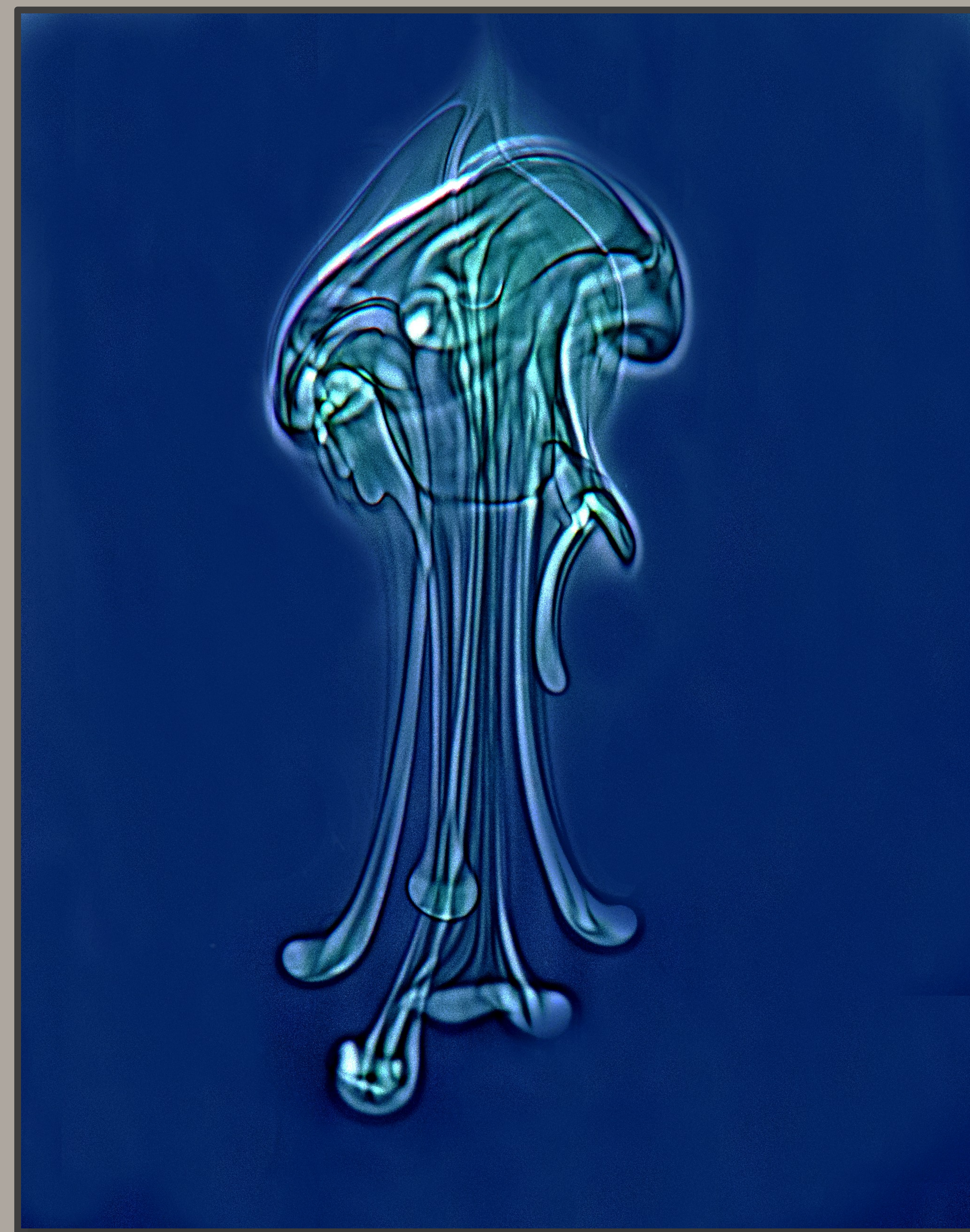

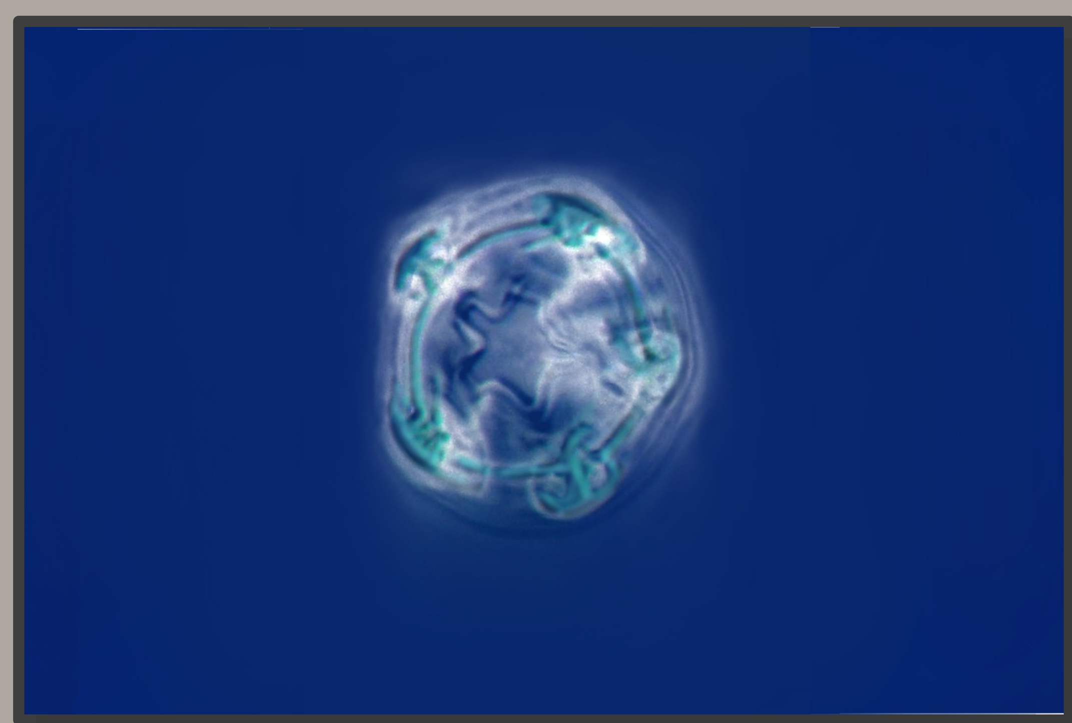

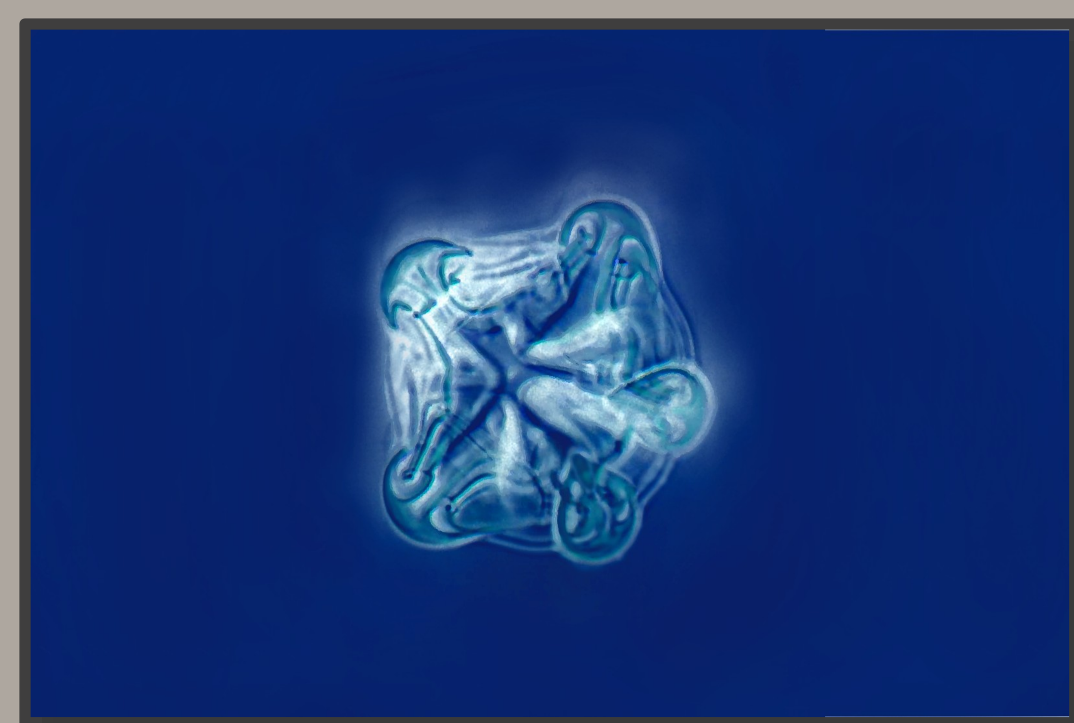

The unstable dynamics of vortex rings settling in a homogeneous fluid is now well understood. Here we consider a vortex with a core heavier than the ambient fluid. In addition, the ambient fluid is stratified. This stratification is characterized by three regions: a constant density top layer, approximately 2 ring diameters thick, a linear stratification extending over 5 ring diameters and a constant deep layer. In the case of an homogeneous background density, the vortex core expands and its velocity decreases as it travels further down. Once the vortex has reached a critical velocity, the vortex ring is subject to a Rayleigh-Taylor instability leading to the breakup of the ring [1]. The expansion of the ring is caused by a subtle balance of vorticity sources and sinks induced by the background density and entrainment of lighter fluid inside the vortex ring. Traveling through a stratified layer provides extra sources of vorticity on the boundary of the ring, leading to a strong distortion of the core. From left to right, we can see the effect of the extra source of vorticity on the ring. Left panel: the vortex has penetrated the bottom, denser layer. Center panel show the instability due to these sources of vorticity. Top panels: side view, bottom panels: bottom view. Observe the pentagonal symmetry of the growing instability. Right panel shows the late time evolution of the instability, with the top layer entrained light fluid returning upward, though the middle of the ring, creating a "*jelly fish*" pattern.

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Reference: [1] Camassa, R., Khatri, S., McLaughlin, R., Mertens, K., Nenon, D., Smith, C., & Viotti, C. (2013) Numerical simulations and experimental measurements of dense-core vortex rings in a sharply stratified environment. *Comput. Sci. & Disc.* (**6**) 014001