Core dynamics on a vortex column

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Through a detailed study of vortex core dynamics we show that variations in core size play a crucial role in the dynamics in 3D-vortex flows and that they in general cannot be ignored as has previously been assumed. To arrive at this conclusion we examine the core dynamics of an isolated axisymmetric vortex column with a nonuniform core. In this simple and idealized configuration, the effects of the core dynamics are seen most clearly because they are decoupled from other effects, such as interactions with other vortices and selfinduced displacement of the axis. We show analytically that the core dynamics results from a distinct physical mechanism, namely differential rotation along axisymmetric vortex surfaces. Furthermore, we show that the core dynamics is neither pure wavemotion nor pure mass transport, but a combination of both. We show and explain why core dynamics is highly Re-sensitive. Moreover, we find that the core variations—which are likely in practical flow situations—do not disappear by inviscid effects. By examining viscous dissipation we find that core dynamics results in a significantly higher dissipation rate and that dissipation is the only effect that reduces core size variations. In fact, we find that the frequency of the core size oscillations increases with Re, but to a finite limit as Re→∞. A striking, newly observed feature resulting from core dynamics is the appearance and disappearance of low enstrophy pockets inside the vortex.

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