Viscous jet drawing air into a bath

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When filling a glass with water, air bubbles often appear.1 Similarly, the impact of a viscous jet on a bath of the same liquid may trigger air entrainment see Figs. 1 and 2. As the impact velocity is increased, viscous stresses induce deformations of the bath interface, up to the point where surface tension fails to maintain the surface integrity.2 Air is then entrained in the bath (Fig. 2), as a thin film coating the jet before decaying into bubbles (Fig. 3). The entrainment threshold velocity is observed to depend on the fluids,3 but also on the radius of the jet.4 As seen in Fig. 1, the impacting liquid is deformed by the bath before reaching it: The jet spreads out due to its viscosity, which prevents entrainment from occurring; the thinner the jet (low Reynolds numbers), the stronger this effect. Above the entrainment threshold, a micrometric film of air coats the jet, before breaking into bubbles after a few centimeters. Measuring the rate of air entrainment shows that the film thickness is proportional to the jet radius. This is due to the Laplace pressure inside the film of air, which pushes air outward stronger if the jet is thinner.