The speed of rolling droplets

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We analyze the near-rolling motion of two-dimensional nonwetting drops down a gently inclined plane. Inspired by the scaling analysis of Mahadevan and Pomeau [Phys. Fluids **11**, 2449 (1999)], we focus upon the limit of small Bond numbers, $B \ll 1$, where the drop shape is nearly circular and the internal flow is approximately a rigid-body rotation except close to the flat spot at the base of the drop. Our analysis reveals that the leading-order dissipation is contributed by both the flow in the flat-spot region and the correction to rigid-body rotation in the remaining liquid domain. The resulting leading-order approximation for the drop velocity $\mathcal{U}$ is given by $\mu\mathcal{U}/\gamma \sim \alpha/2B \ln \frac{1}{B}$, wherein μ is the liquid viscosity, γ the interfacial tension, and α the inclination angle.