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ON THE JET-DRIVEN AXISYMMETRIC THIN LIQUID FILM OVER A SPINNING DISC

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We consider the steady laminar annular spread of a thin liquid film generated by a circular jet impinging perpendicularly in direction of gravity on the centre of a horizontally rotating disc (figure 1). The individual flow regimes arising due to the largeness of the Reynolds number formed with the radius of the jet, its slenderness, and the relative magnitude of the centrifugal force measured by a suitably defined Rossby number *Ro* are examined both analytically and numerically. Matched asymptotic expansions of the flow quantities provide the proper means to clarify open issues concerning the asymptotic structure of the developed viscous film. A careful analysis of jet impingement predicts a negligibly small influence of gravity and surface tension on the film flow, considered in the spirit of a shallow-water approach. Accordingly, associated downstream conditions are disregarded due to two essential properties of the flow:

- the relevant Froude and Weber numbers are sufficiently large;
- given a sufficiently large disc radius, the height of the liquid layer undergoes a maximum the location and magnitude of which is controlled in by the disc spin.

Specifically, the latter mechanism represses the typical (quadratic) radial growth of the height and associated increasing influence of gravity, known from the classical studies of the flow past a disc at rest. Hence, the parabolic free-surface problem shaped out from the governing equations describes a very supercritical spread of the film past an infinite disc, solely controlled by the vorticity and Froude and Weber numbers governing the jet flow and *Ro*. Its numerical solutions are discussed for a wide range of *Ro*. The surprising richness of flow phenomena is studied rigorously in a systematic manner. Special emphasis lies on the limits of small (i) and large (ii) values of *Ro*: (i) refers to relatively high disc spin and implies a delicate breakdown of the asymptotic flow structure near the jet, thus requiring a specific treatment; (ii) to a canonical representation of the flow (figure 2) and the increasing (initially neglected) impact of gravity, surface tension, and the trailing disc edge, rendering the problem weakly elliptic. The associated emergence of a (for rotating flows yet poorly understood) hydraulic jump and its radial position and internal structure are envisaged in brief.

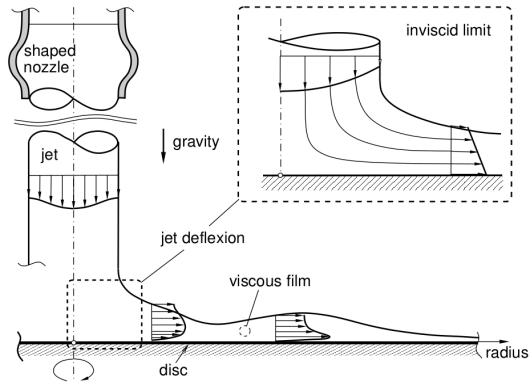

Fig. 1: Flow configuration and detail of (predominantly inviscid) jet bending.

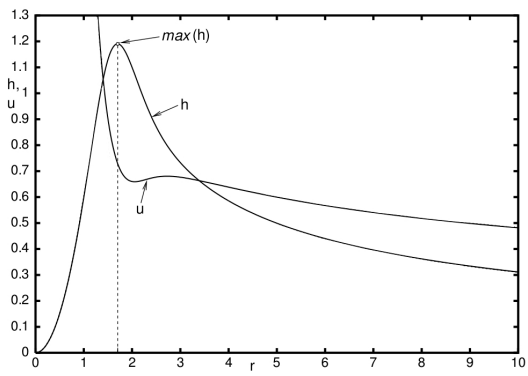

Fig.2: Numerical results, properly non-dimensional/scaled: film height h, surface speed u, radius r.