

Expansion Procedures for the Euler's Equations for Rotating Fluids

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Summary. The equations describing the motion of solids in incompressible, inviscid, rotating fluids have been expressed in non-dimensional form. Using the technique of "coordinate stretching", the procedures for developing asymptotic expansions of the exact solutions for small and large ROSSBY numbers are given and the range of validity of these expansions is discussed. The asymptotic expansions of the exact solutions, when the motion is steady, have been obtained. It is found that the expansions of the type predicted by the theory exist only for large ROSSBY numbers.

1. Introduction. The motion of a body in a fluid which is inviscid and incompressible and which has a uniform angular velocity far away from the body is a subject of considerable interest. The various problems which have been worked out so far are based on one of the two following lines of approach. The first approach consists in assuming at the very outset a steady state motion. Thus the possibility of posing initial value problems and the determination of their relation with the steady state solution is completely ruled out. In steady motion, by superposing a constant velocity on the whole field the body is brought to rest and the motion of the fluid far away from the body is characterized by a uniform rotation Ω and a uniform translation U along the axis of rotation. The non-linear equations of motion with these conditions at infinity, in the case of axisymmetrical motion, reduce to one linear differential equation for STOKES' stream function Ψ , LONG [1], NIGAM [2],

$$\frac{\partial^2 \Psi}{\partial x^2} + \frac{\partial^2 \Psi}{\partial \rho^2} - \frac{1}{\rho} \frac{\partial \Psi}{\partial \rho} + \frac{4\Omega^2}{U^2} \Psi = -\frac{2\Omega^2}{U} \rho^2.$$

This equation has been used to discuss the motion past a sphere by TAYLOR [3], LONG [1], for motion past a spheroid, a disk and a paraboloid of revolution by FADNIS [4] and for motion created by sources and sinks at the axis by LONG [5]. The same equation forms the basis of the investigations of FRAENKEL [6] and STEWARTSON [7]. The solutions of TAYLOR and FADNIS for an unbounded