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On the Theory for Subsonic, Transonic and Supersonic Flows in Water with Supercavitation

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The aim of this investigation is to improve the understanding of physical and mathematical aspects of hydrodynamics of flows at super high speeds, typically at sonic speed of water, which is of the order of 1500 m/s. Super high speed motion in water is realized with the help of lunching small axisymmetric projectiles of $\sim 0.2 - -0.7$ kg mass with initial speeds of $\sim 1000 - -2000$ m/s and by following its stable motion under inertia. Under these conditions the body is totally surrounded by a vapor filled cavity, which prevents direct contact of the projectile with the liquid fluid. Therefore, the viscous losses are considerably reduced, which implies the potential to achieve a very low total drag, comparable to that of high speed motion in air. Following the classical incompressible supercavitation modelling, the linearized approach, based on the Slender Body Theory, the Matched Asymptotic Method and by using simple heuristic models, together with integral conservation laws, and similarity consideration are applied for this analysis. With respect to the existence of a considerable more extended transonic regime in water flows, as compared to the classical case of air/gas flows, special attention is paid to the investigation of singularities of transonic water flows. As a result of the development of the second order theory a number of simple solutions have been found that give the possibility to analyze compressibility effects for super high speed motion in water as a whole.

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