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Weak Shock Wave Reflections and Transitions

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Abstract

Shock waves, their reflections, and transitions are an essential part of compressible high-speed flows. The nature of shock wave reflections entirely differs as the flow regime changes from steady to pseudo-steady and unsteady flow. So are the criteria governing the shock wave transition. One major classification in shock wave reflections is the strong and weak shock reflection domains, based on the flow being supersonic or subsonic, respectively, behind the reflected shock wave. The weak shock reflections are characterized by the curved nature of the reflected shock wave and the subsonic non-uniform flow downstream of it, which makes the flow analysis quite challenging. The present study focuses on the shock reflections and transitions in the weak shock reflection domain.

A Mach reflection is one of the common types of irregular reflection and the height of the Mach stem remains as the single length scale in a supersonic flow. Though many analytical studies estimate the height of the Mach stem in the strong shock reflection domain, there are hardly any studies in the weak shock reflection domain. In the present work, two methods have been proposed to estimate the Mach stem height for asymmetric Mach reflection in the weak shock reflection domain. Computational simulations using an in-house WENO (Weighted Essentially Non-Oscillatory) code were also carried out to resolve the flow fields and compared with the analytical results.

The behavior of transient shock wave reflections over surfaces with more than one shock transition is complex to analyze compared to the steady transitions but is also important in many engineering applications. Such a coupled geometry with a convex-concave ramp of equal radii followed by a planar surface has been analyzed experimentally and numerically in this study. Many interesting flow features such as shock wave transitions over the ramp, characteristics of the induced flow behind the shock wave, and the development of a stationary separation shock wave have been observed in the study. While the shock wave transitions over the ramp are found to depend mainly on the ramp geometry, the characteristics of the stationary shock wave and the flow separation in the concave region of the ramp surface have been found to be varying with the shock wave Mach numbers.