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The compressible shear layer of a Mach Reflection

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Abstract

The Mach Reflection occurring in pseudo-steady flows has been studied for well over a century. A Mach Reflection consists of incident and reflected shocks, a Mach stem and a shear layer. Three Shock Theory proposed by von Neumann in the 1940's shows good agreement to experimental data in the strong shock domain ($M_s > 2$) however, poor agreement is obtained in the weak shock domain ($M_s < 1.5$).

A pseudo-steady Single Mach Reflection (SMR) was studied in a large scale facility for a single wedge angle, a complimentary study was undertaken in a conventional shock tube over a wide range of wedge angles. The Mach numbers used were in the range $1.27 \leq M_s \leq 1.59$ and the wedge angles $25^\circ \leq \theta_w \leq 38^\circ$. A shadowgraph flow visualisation system was used in conjunction with a single shot camera to obtain high resolution images. Various shock angles were measured as well as the triple point trajectory from the leading edge of the wedge. As expected, poor agreement to Three Shock Theory was obtained in the current (M_s, θ_w) domain.

The spread angle of the shear layer was measured from the triple point. An oblique shock analysis was used to obtain the theoretical velocity and density ratio across the shear layer as well as other properties such as shear velocity (ΔU) and convective Mach number (M_c). The analysis revealed that the effect of compressibility on the growth of the shear layer was negligible. The spread angle increased with increasing incident shock strength and wedge angle. A comparison to the theoretical models of Papamoschou and Rikanati et al. showed good agreement for some wedge angles and intermediate Mach numbers. Recommendations for future work include increasing the Mach number and wedge angle range as well as the implementation of different flow visualisation setups.