Two-dimensional Compressible Flows

It is useful to begin the discussion of two-dimensional compressible flows with the following thought experiment. Consider a very small object or disturbance traveling at a velocity u through a compressible

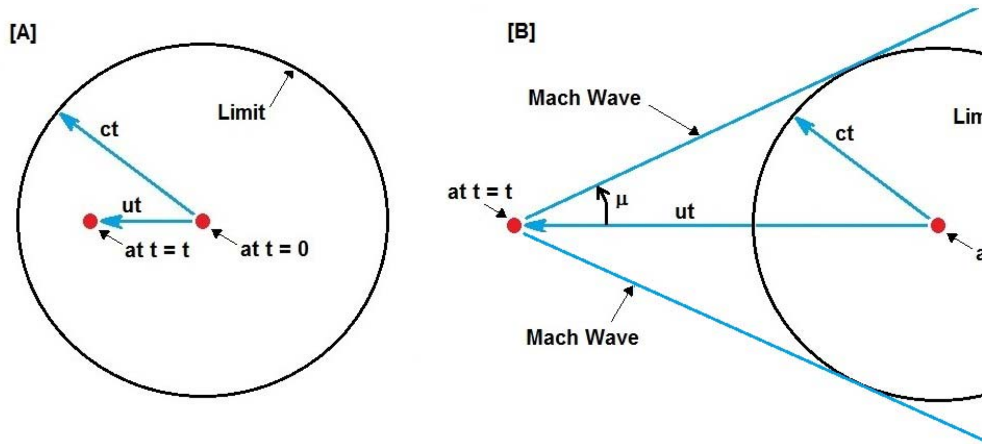

Figure 1: Propagation of information in [A] subsonic flow and [B] supersonic flow.

fluid that has a speed of sound equal to c. If $c > u$ ($M < 1$) then, as depicted in Figure 1[A], any fluid disturbance created by the object will travel faster than the object and consequently all the fluid ahead of that object will, to some degree, sense the motion of the object. On the other hand, as depicted in Figure 1[B], if $c < u$ ($M > 1$) the disturbances generated by the object cannot travel fast enough to get beyond a triangular region around the object defined by the angle, μ (not to be confused with the viscosity). This known as the *Mach angle* and, by simple trigonometry, is given by

$$\sin\mu \;=\; \frac{1}{M} \qquad \text{(Boj1)}$$

Note that no Mach angle exists if $M < 1$.

Since only part of the physical space in a supersonic flow is affected by the fluid motions it follows that supersonic flows are more readily analyzed than subsonic flows. In the next sections we detail some of the methods used to analyze supersonic flows. We begin with supersonic flows that exhibit angles of turn which are sufficiently small that terms that are quadratic (or higher order) in that small angle can be neglected. In the following section we address supersonic flows that involve larger angles of turn.