Waves in 1-D Compressible Flow

Imagine we have a steady 1-D compressible flow. Then suppose a small disturbance occurs at a location $x = x_o$. This disturbance will cause waves to propagate away from the source. Suppose that the flow velocity were u and the speed of sound a. Then 3 waves exist:

(1) Downstream propagating acoustic wave:
Speed: $u + a$
This is an isentropic disturbance (and what is commonly called a sound wave).

(2) Upstream propagating acoustic wave:
Speed: $u - a$
Again, this is an isentropic disturbance (and is commonly called a sound wave).

(3) Entropy wave:
Speed: $u \rightarrow$ This wave is just a change in entropy.

When $M = \frac{|u|}{a} > 1$, all the waves propagate in the downstream direction:

For example, if $u > a > 0$, then

$$\boxed{u, u + a, u - a > 0}$$

Supersonic flow
Waves travel only downstream

When $M = \frac{|u|}{a} < 1$, the slow acoustic wave propagates against the stream:

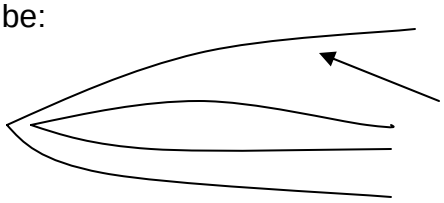
For example, if $a > u > 0$ then

$$\boxed{\begin{array}{l} u, u + a > 0 \\ u - a < 0 \end{array}}$$

Subsonic flow
Waves travel up and downstream

In supersonic flow, this means that the presence of a disturbance cannot be felt upstream while in a subsonic flow it can be:

$M_\infty > 1$ Disturbance not felt upstream



Shock wave