A Short Excursion into the Theory of Sound

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Abstract

The traditional theory of sound is based on a number of assumptions which lead to the wave equation. We re-examine the foundations of the theory from the point of view of compressible fluid mechanics and thermodynamics. In the case of sonic vibrations in one spatial dimension this yields, after scaling to dimensionless variables, the system of first order differenrial equations

$$vt(x,t) + p_x(x,t) = 0; \tag{1}$$

$$p_t(x,t) + \frac{v_x(x,t)}{(1+r(x,t))^2} = 0; \tag{2}$$

$$r_t(x,t) + v_x(x,t) = 0; \tag{3}$$

with v, p and r the velocity, pressure and *compressibility* respectively. The traditional approach is to neglect the natural thermodynamic quantity r. When it is retained, the problem is more interesting.