Liebau Phenomenon

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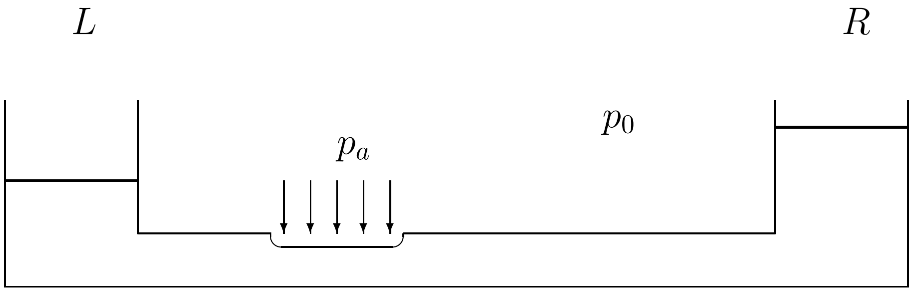
Objective: Accurare numerical investigation of the valveless pumping effect known as Liebau phenomenon.



A valveless pump.

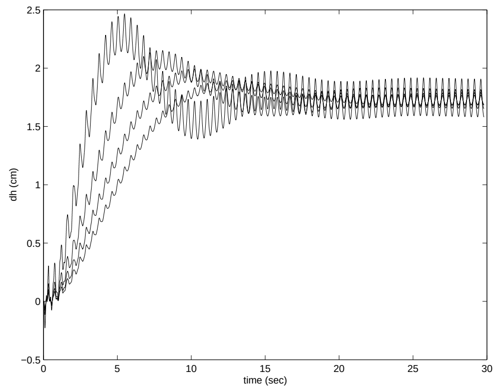
Applications: Pumping in cardiovascular systems, design of micro-pumps.

Model for flow in elastic tubes:

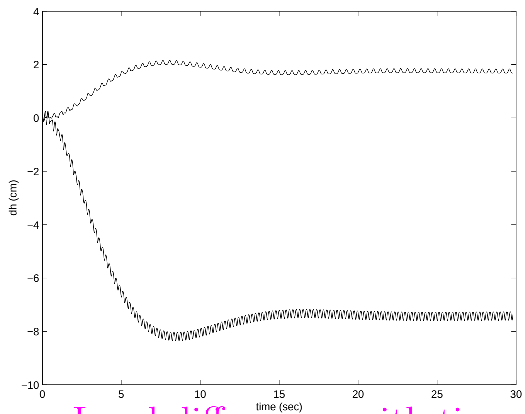
$$\frac{\partial w}{\partial t} + w\frac{\partial w}{\partial x} + \frac{1}{\rho}\frac{\partial p}{\partial x} = -\frac{1}{\rho}\frac{\partial p_\nu}{\partial x}, \qquad \frac{\partial p}{\partial t} + w\frac{\partial p}{\partial x} + \rho a^2\frac{\partial w}{\partial x} = \frac{\partial p_a}{\partial t} + w\frac{\partial p_a}{\partial x}. \qquad (1)$$

Forcing term

$$p_a(x,t) = p_0 + 2\,p_0\frac{(x-x_L)(x_R-x)}{(x_R-x_L)^2}\,\sin\omega t.$$



Level differences with time for $n_A = 25, 50, 75, 100$.



Level differences with time for $\omega = 14.6$ and $\omega = 29.2$ (negative dh)

Similar behavior is observed with rigid pipes:

$$\frac{d}{dt}w^- = p_1^b - p_2^b - p_1^e + p_2^e - p_1^v + p_2^v, \qquad \frac{d}{dt}h_i = \frac{A_0}{A_B}w_i, \quad i = 1,2 \qquad w^+(t) = \frac{A_c S_p \omega}{A_0}\cos(\omega t + \delta)$$