Karlsruher Institut für Technologie

Institut für Technische Mechanik
- Dynamik und Mechatronik -

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Bachelor/Master thesis

On the Impact of Nonlinear Damping on the Safe Basins of Escape from a One-Dimensional Potential Well

Background

The escape phenomenon is a classic problem in engineering and natural sciences. The phenomenon occurs whenever a particle or a system of particles leaves a limited potential well and does not return to it. Escape is present at any scales of physics, from atomic sizes, such as reaction of molecules up to the magnitudes of celestial mechanics, like the collapse of galaxies. Such everyday phenomena as the capsizing of vessels or dynamic buckling of beams are all related to escape dynamics.

At the Institute of Engineering Mechanics (ITM), we investigate several aspects of escape: impacts of initial conditions, potential shape, external forcing, damping etc. In case of unexcited escape, a relatively simple 1 DoF benchmark model is given es follows.

$$\ddot{x} + F_d(x, \dot{x}) + V'(x) = 0$$

$F_d(x, \dot{x})$ is a displacement and velocity dependent damping force, and $V'(x)$ is the restoring force of the potential $V(x)$; for example, a particle in a quadratic-cubic potential well with additional air drag (see Fig. 1)**.** For some choice of the parameters and initial conditions (x_0, u_0), the particle remains in the potential well (*safe basin*), for another set of parameters, however, the particle escapes. For the above-mentioned example, the location of the safe basin has been determined numerically in Fig. 2 using $V'(x) = x - x^2$ and $F_d(\dot{x}) = 0.5\ \mathrm{sign}(x)\dot{x}^2$.

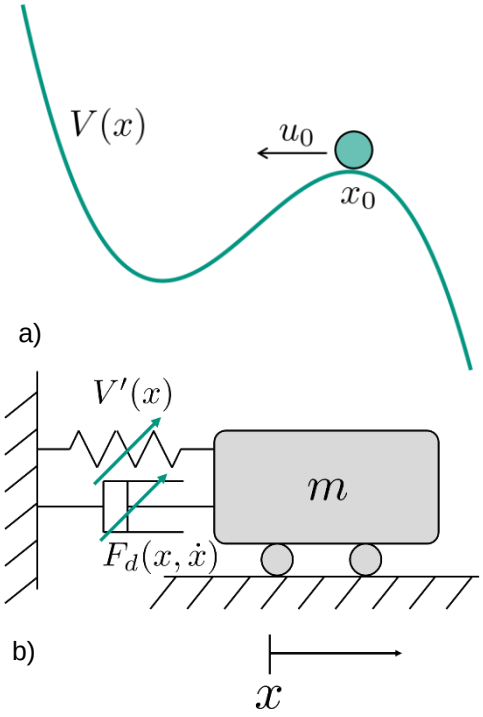

Figure 1a) – Quadratic-quartic potential
Figure 1b) – Homologous mechanical model of the problem

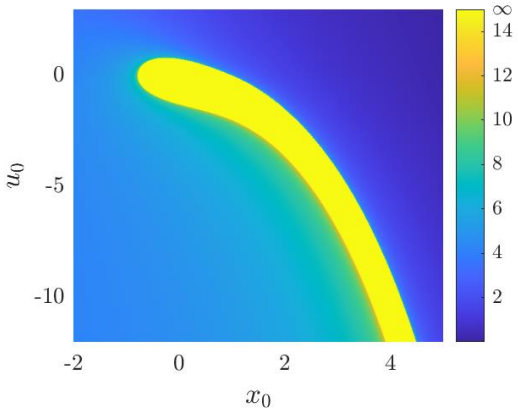

Figure 2 – Escape time and safe basin for $\ddot{x} + \dot{x}|\dot{x}| + x - x^2 = 0$

Topic

The aim of the Bachelor/Master thesis is to investigate the impact of different kinds of nonlinear damping (Coulomb friction, air drag, van der Pol oscillator, etc.) on the size and location of the safe basins of escape for various potentials.

Requirements

- Strong mathematical background
- Programming skills in MATLAB or in a similar programming language

Start: immediately

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