71

Particle escape from potential well under high-frequency external forcing

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Abstract

This paper studies the escape dynamics of periodically forced particle from a potential well. The excitation frequency is assumed to be substantially higher than the natural frequency of the potential well at the stable equilibrium. At this stage, damping is neglected, and the quadratic-quartic Duffing potential oscillator is considered. The paper analyses two main problems: (i) The escape threshold – for fixed initial conditions (IC), the combination of the excitation parameters that correspond to the escape transition are determined (F, Ω and ψ are the excitation force amplitude, frequency and phase). (ii) The safe basin – for a given set of the excitation parameters, the set of the non-escaping IC is determined. The approximate analytic solution is obtained as a sum of fast and slow components and is compared to the numerical results. The first primary problem is to determine the critical F for escape as a function of Ω. Approximations of the amplitude equation are performed for different phases and zero IC. The results show a good correspondence between the numerical results and the analytic approximations. For the safe basin problem, we analytically demonstrate that the boundary of the non-escaping IC region is a unity of two parabolic fragments. In this case, significant discrepancies between the numerical and analytical solutions are identified for unusual F-value cases. By analyzing the causes of these differences, we aim to gain a deeper understanding of the dynamics of the Duffing oscillator.

Keywords: Escape, Duffing oscillator, Potential well.

Categories

TND: Transient and Non-stationary Dynamics