On the escape of a resonantly excited couple of particles from a potential well

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Abstract. Escape dynamics of a damped two particles system in a truncated potential well under bi-harmonic excitation are investigated. It is assumed that excitation frequencies are tuned to the modal natural frequency of the relative motion and to the modal frequency of the centre of mass on the bottom of the potential well. Although the escape is an essentially non-stationary process, the critical force strongly depends on the stationary amplitude of the relative vibrations within the pair of masses. The characteristic escape curve for the critical force moves up with the increasing relative vibrations at least for the investigated potentials.

Introduction

Escape form a potential well is a classic problem arising in various fields of natural science [1] and engineering [2]. Escape can be caused by different types of excitation starting with the appropriate initial conditions via harmonic excitation [1] to stochastic noise [2] and impact loadings. Two basic mechanisms for the escape of a single particle under resonant harmonic excitation have been identified in [3] – the maximum mechanism and the saddle point mechanism. The last analysis was based on the system reduction to the slow manifold and analysis of the corresponding limiting phase trajectories. In the present paper we consider a more complex situation. A system of two coupled particles (cf. Fig. 1a) is excited by a sum of two harmonic components. The first one corresponds (in linear case) to the internal mode of the couple corresponding to their relative oscillations. The second one is close to the 1:1 resonance for the centre of mass of the system.

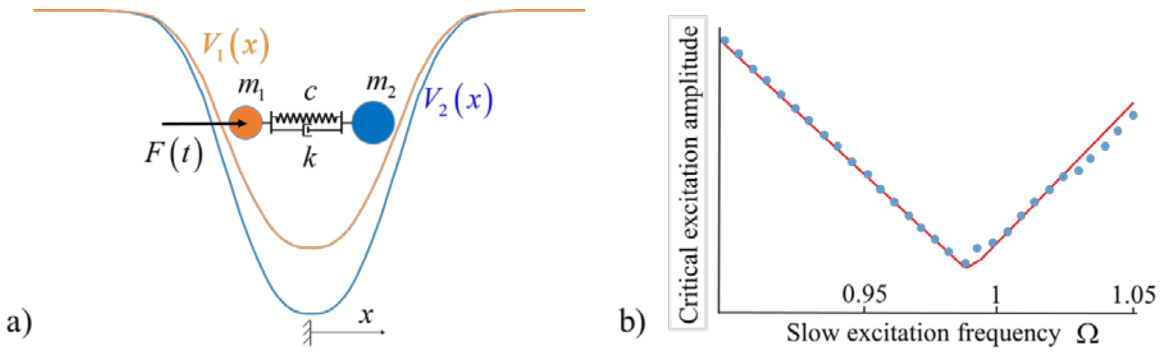

Figure 1: a) The scheme of the problem; b) the critical level of the amplitude of the slow part of the external excitation vs. slow excitation frequency at a certain level of the internal vibration of the two mass system.

Results and discussion

Supposing the stiffness between the particles to be sufficiently large and the corresponding damping to be non-small the averaging approach for strongly damped systems can [4] be applied in order to achieve the necessary system reduction. The subsequent analysis can be performed utilizing the smoothened averaged potential which takes into account that the frequency of the relative oscillations is significantly higher than the frequency of the centre of mass. Analytical expressions for the equation governing the slow dynamics (a single first order differential equation) are obtained for several types of the potential well. These results (red line) are compared with the direct numerical simulations of the original system showing an acceptable accuracy of the approximate approach (cf. Fig. 1b, blue dots). The main effect is the stabilization of the two particle system in the potential well. Increasing intensity of the relative vibration increases the critical level of the low frequency excitation which is necessary for the escape. The whole escape curve well known from the previous investigations is shifted up and stretched increasing the relevant frequency range. These changes can be interpreted as an effect of the modified effective potential alongside with the energy dissipation due to the internal damping.

References

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