The suitcase instability

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We study the rocking instability of a rolling suitcase both experimentally and theoretically. Experiments are performed with a toy-model of a suitcase held by a CV joint and rolling on a treadmill moving at constant speed. When the suitcase is perturbed, *e.g.* by lifting one wheel, rocking oscillations from one wheel to the other are observed. When the velocity is sufficiently large the perturbed system is unstable and stationary oscillations may be observed. This subcritical behavior differs from previous theoretical studies where the rocking motion is driven by a periodic external forcing [1]. The suitcase instability is caused by the non-sliding condition of the suitcase wheels when rolling on the treadmill. Because axes of rotation of the suitcase are not perpendicular to the the rolling axes of wheels, a rocking motion induces a translation and the suitcase can gain energy. A theoretical model is developed under very few assumptions following the work of Flannery on non-holonomic constraints and Lagrange multipliers [2]. Interestingly, the rocking suitcase cannot simultaneously conserve energy and angular momentum as already observed in similar systems [3]. Numerical simulations are presented for the theoretical model and comparisons with experiments are reported. Finally, we propose a simplified phenomenological theoretical model, which reproduces the main characteristic of the instability by numerical simulations and experiments and helps to understand the physical mechanisms at play.

Références

1. R. H. Plaut *Rocking instability of a pulled suitcase with two wheels*, ACTA MECHANICA **117** 165-179 (1996).
2. J. Flannery, *The enigma of nonholonomic constraints*, AJP, 2005.
3. G. Augusti, A. Sinopoli *Modelling the dynamics of large block structures.*, Meccanica **27** 195-211.