Facchini, G.; Sekimoto, K.; Courrech du Pont, S.
The rolling suitcase instability: a coupling between translation and rotation. (English)
[Zbl 1402.70006]

Summary: A two-wheel suitcase or trolley can exhibit undamped rocking oscillations from one wheel to
the other when pulled fast enough. We study this instability both experimentally – with a toy model of
a suitcase rolling on a treadmill – and theoretically. The suitcase oscillates only if a finite perturbation is
applied. This is because intrinsic dissipation occurs when the supporting wheel switches. When unstable,
the suitcase either increasingly rocks until overturning or reaches a stable limit cycle. The friction force at
the rolling wheels constrains wheels to roll without slipping. This constraint imposes a coupling between
the translational motion and the three-dimensional rotational motion of the suitcase that drives the
rocking instability. The same behaviours are observed in the experiments and in the simulations. The
asymptotic scaling laws we observe in the simulations are explained by means of a simplified model where
the coupling force is explicit.

MSC:
70E18 Motion of a rigid body in contact with a solid surface

Keywords:
rolling suitcase; instability; non-holonomic constraint; everyday life physics; dynamical system

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