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Duffing equation describes sloshing experiments KERSTIN AVILA, BASTIAN BÄUERLEIN, Center of Applied Space Technology and Microgravity (ZARM), University of Bremen, 28359 Bremen, Germany — In nature and in engineering, periodic forcing leads often to nonlinear resonances which are challenging to model and predict. The Duffing equation ($\ddot{x} + \delta\dot{x} + \beta x + \alpha x^3 = F\cos\omega t$) is the simplest and most widely studied model describing such phenomena and is thus used in introductory courses to nonlinear dynamics. Despite numerous analytical and numerical studies across disciplines investigating its properties and dynamics, laboratory experiments exhibiting its dynamics are very scarce and, to our knowledge, all of them have been constructed to behave as a Duffing oscillator. We show that sloshing of water in a rectangular container driven by harmonic horizontal excitation is accurately described by the Duffing equation. The choice of the setup combined with automated flow visualizations and PIV-measurements allow it to reproduce key features of the Duffing oscillator experimentally. Besides the characteristic resonance curve we observe a hysteresis which increases with the driving amplitude and features transitions at exactly 90°-phase-lag, as well as period-three-motion. The experiments reach from linear and nonlinear dynamics fully described by the Duffing oscillator, up to highly nonlinear effects with e.g. breaking surface waves.

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