Bouncing dynamics leads to the chaotic interaction of two walkers

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A droplet bouncing on a vertically vibrated bath may be propelled horizontally by the Faraday waves that it generates at each rebound. This association of a wave and a particle is called a walker. Ten years ago, Yves Couder[1] and co-workers noted that the dynamical encounter of two walkers may lead to either scattered trajectories or orbital motion. Here, we systematically investigate the interaction of two walkers. These latter are launched one against the other with finely controlled initial conditions. Output trajectories are classified in four types: scattering, orbiting, promenade and complex. We report that under measurement precision, the output results are stochastic. For a given set of initial parameters, different output trajectories are observed.

For ten years, this particle-wave duality has been investigated with the hope that it would be a macroscopic analogue to quantum mechanics. One major argument to exclude this experiment as a quantum analogue is the missing link between the purely probabilistic theory of quantum mechanics and the determinism of the macroscopic world. For one walker far from any boundary, extremely similar initial trajectories give extremely similar outputs. For two walkers, this is not true. We observe here that, although deterministic, this experiment is extremely sensitive to parameters. Where does this chaos come from?

High-frequency visualisations of the interaction show that droplets desynchronise one another. The time between two consecutive impacts of a droplet may differ from the Faraday period. The discrete model developed by Couder's team[2] and the continuous

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[1] Couder et al. (2005), Dynamical phenomena: Walking and orbiting droplets, *Nature* **437**, 208

[2] Eddi et al. (2011), Information stored in Faraday waves: the origin of a path memory, *J. Fluid Mech.* **674**, 433-463

model developed by Bush's team[3], both rely on the assumption of constant impact phase, or strobe hypothesis. Although those models described very well the walk of a single droplet, they fail to capture several key features of the interaction of two walkers. In order to keep things minimal, we extend the discrete inelastic bouncing model of Eddi (2011). We add vertical dynamics to account for bouncing phase variations. Basic numerical simulations show that sensibility to parameters comes from the variation of impact phase (desynchronization) of the walkers with the driving of the bath.
Finally, we adopt the de Broglie point of view to discuss the possibility of such mechanism being responsible for probabilistic description of the quantum world.

This work is supported by the ARC Quandrops of the Belgium Wallonia-Brussels Federation.

[3] Molàcek & Bush (2013), Drops walking on a vibrating bath: towards a hydrodynamic pilot-wave theory,
J. Fluid Mech. **727**, 612-647

http://labos.ulg.ac.be/microfluidics/current-research/bouncing-droplets-vs-quantum-mechanics/