WHERE `UNPREDICTABILITY' SHADES OFF : THE TUNNELLING OF BOUNCING DROPLETS

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Classical point mechanics offers a fairly simple view of the crossing of a barrier of potential. A particle always crosses a potential barrier if its kinetic energy K is larger than the potential energy Ep of the barrier. On the contrary, if K < Ep, it will always be reflected by the barrier. In quantum mechanics, the crossing of a barrier of potential is not as simple : a particle with K < Ep has a non-zero probability of crossing the barrier. This is called the tunnelling effect. Conversely, a particle with K>Ep also has a non-zero probability of being reflected.

The random character of the crossing of a repulsive barrier by a macroscopic object was reported by A. Eddi in 2009 [1]. These objects, *the walkers*, are millimeter-sized oil droplets bouncing on a vertically vibrated oil bath. Successive rebounds create waves on the surface of the bath, which in turn guide the droplet: walkers therefore represent a tight association of a particle and a wave at the macroscopic scale [2,3,4]. When a walker is sent to the repulsive barrier, it may pass through it or be reflected -- apparently randomly.

In this work, we revisit the tunnelling of walkers with unprecendented experimental accuracy in order to understand where and how the impredictability of the interaction outcome (crossing vs. reflexion) shades off. We show that this outcome is not directly related to the kinetic energy of the walker. Instead, a variation of the fast dynamic (vertical rebounds) during interaction with the barrier is responsible for the aparent randomness [5]. These experimental results are compared to those of a numerical simulation of the quantum tunnelling effect. We determine the trajectory of the quantum particle launched towards a barrier of potential thanks to measurements of position and momentum at regular time intervals. We observe that, similarly to walkers, the 'unpredictability' of the interaction outcome of a quantum particle is unveiled at the foot of the potential barrier.

ACKNOWLEDGEMENTS: This work was financially supported by the FNRS grant number CHAR. RECH.-1.B423.18 (Tadrist L.).

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