

Magnetic levitation in the field of a rotating dipole – Supplemental material

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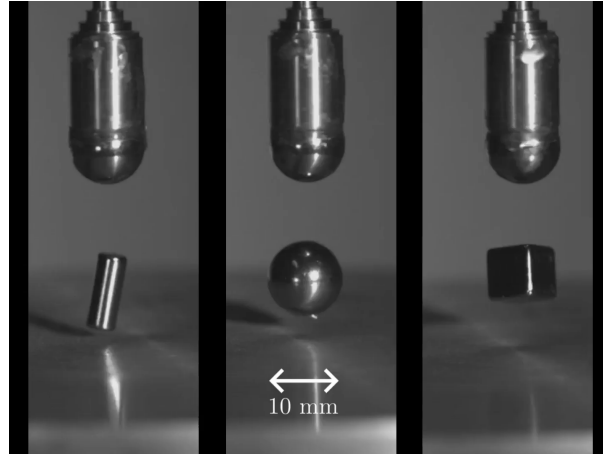
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A. Movie S1



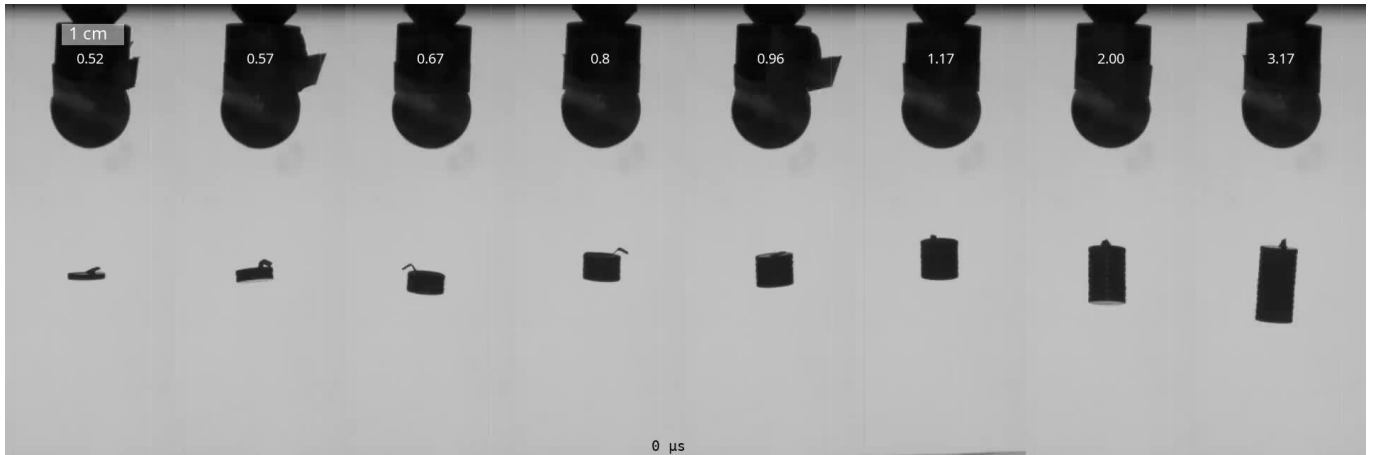
Short extract of a typical experimental video taken with a high-speed camera (Chronos CR14-1.0) at a rate of 8810 frames per seconds. The top magnet (12.7 mm diameter spherical magnet of remanence 1.32 ± 0.03 T) is rotated at a rate of $f = 216 \pm 2$ Hz and the bottom magnet (a cylinder of 5 mm radius, 5 mm height of remanence 1.35 ± 0.02 T) can be seen precessing underneath. A small wire of negligible weight have been attached to the levitating magnet to easily visualize and measure its rotation around its symmetry axis (spin).

B. Movie S2



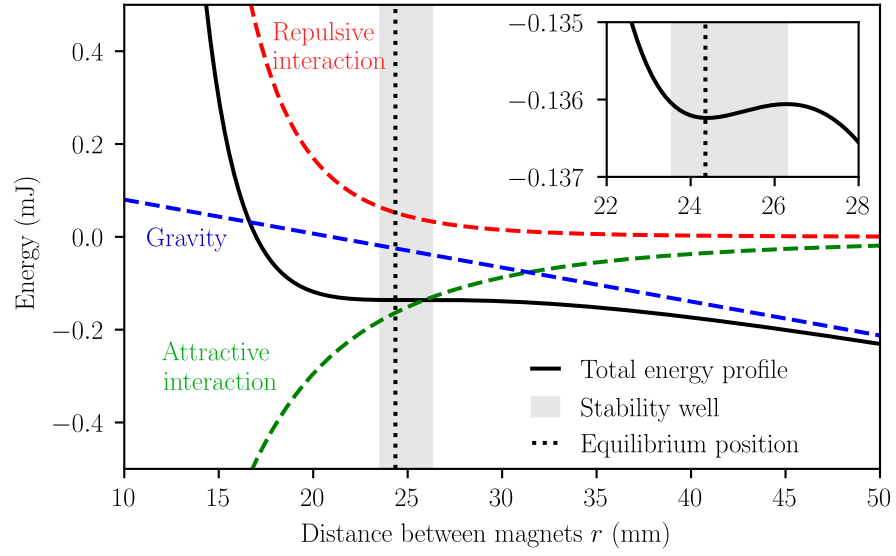
Demonstration of different shapes of magnets (cylindrical, spherical and cubic) levitating. One can see in these movies that the levitating magnet is precessing but not spinning around its magnetic axis. The rotating magnet is a 10 mm sphere with rotation speed is $f = 144$ Hz. All magnets are made of NdFeB (remanence 1.29 T to 1.32 T). The camera used for video acquisition is a Chronos 1.4 (Krontech), used with frame rate 10 000 fps. On the video, one can see an aluminum block below the levitating magnet. For experiments presented in section III.B., this block serves as an inductive damper which stabilizes the movement of the levitating magnet during both initialization and recording, allowing for longer acquisition times. This block is placed below the levitating magnet at a distance a few times greater than the distance separating it from the rotor, and its presence does not change the various measurements we performed.

C. Movie S3



Demonstration of the levitation of cylindrical permanent magnets of various aspect ratios. The rotor (12.7 mm diameter spherical magnet of remanence 1.32 ± 0.03 T) rotation rate is different for each magnet, which explains the difference in levitation height. The text overlay on the rotating magnet is the ratio of ortho-axial over axial moments of inertia for the corresponding levitating magnet. It is given by the expression $1/2 + 2(h/d)^2/3$ for a solid cylinder of height h and diameter d . The levitating magnet is a single disc of $d = 6$ mm diameter and $h = 1$ mm height with remanence 1.34 ± 0.02 T on the leftmost recording, and a stack of respectively 2, 3, 4, 5, 6, 9 and 12 of identical discs on the others. The acquisition was made using a high-speed camera (Chronos CR14-1.0), with a frame rate of 8810 frames per second.

D. S4: Energy profile for the experiments presented Fig. 5 and Fig. 6



Potential energy diagram as a function of the distance between magnets r , the numerical values corresponding to the parameters of the experiments Fig. 5 and Fig. 6 (given in the main text).