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Bubble-based acoustic swimmers: a dual micro/macro-fluidics study NICOLAS BERTIN, LIPHY CNRS UMR5588 - Univ Grenoble Alpes, TAMSIN SPELMAN, DAMTP Univ of Cambridge, OLIVIER STPHAN, LIPHY CNRS UMR5588 - Univ Grenoble Alpes, ERIC LAUGA, DAMTP Univ of Cambridge, PHILIPPE MARMOTTANT, LIPHY CNRS UMR5588 - Univ Grenoble Alpes — Without protection, a micron-sized free air bubble at room temperature in water has a life duration shorter than a few tens of seconds. Using two-photon lithography, which is similar to 3D printing at the micron scale, we can build "armors" for these bubbles: micro-capsules with an opening. These armors contain the bubble and extend its lifespan to several hours in biological buffer solutions. When excited by an external ultrasonic wave, the bubble performs large amplitude oscillations at the capsule opening and generates a powerful acoustic streaming flow (velocity up to dozens of mm/s). We show how to obtain blood-vessel-sized acoustic swimmers for drug-delivery applications. They contain multiple capsules of different aperture sizes: this makes them resonant at different frequencies. By adjusting the frequency, we can adjust the swimming direction. A micro/macro parallel study is also performed. On one hand, we study microswimmers on the 20-50 m scale: propulsion forces are measured and predicted. On the other hand, we study macroscopic "milliswimmers" containing bubbles that are 2 to 10 mm in diameter, allowing us to understand in detail the modes of vibration, to quantitatively predict the swimming motions and inspire new designs for microswimmers.

Nicolas Bertin
LIPHY CNRS UMR5588 - Univ Grenoble Alpes

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