The 3D dynamics of wall-entrapment in swimming bacteria

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Swimming bacteria display a remarkable tendency to move along flat surfaces for prolonged times [1]. This behavior may have a biological importance but can also be exploited by using microfabricated structures to manipulate bacteria [2]. We demonstrate that, by using a combination of 3-axis holographic microscopy and optical tweezers, it is possible to reconstruct the full 3D entrapment dynamics of swimming *E. coli* cells that are sequentially released at a controlled distance and angle from a flat solid wall. We could resolve the three main stages of wall entrapment (approach, alignment, surface swimming) and quantitatively gauge the relative importance of the physical mechanisms that are involved in each of them. We found that cell alignment is governed by steric forces while hydrodynamics is needed to account for stable surface swimming. We also found that wobbling, i.e. a precession motion of the cell body axis around the swimming direction, plays an important role in determining both the swimming pitch angle and distance from the wall. Finally, by studying swimming near microfabricated pillars of variable size, we show that cell entrapment is also present for convex walls, although it is markedly reduced below a characteristic pillar radius [3].

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