Curvature dependent dynamics of a bacterium confined in a giant unilamellar vesicle

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Giant unilamellar vesicles (GUVs) provide a controllable, cell-sized membrane environment well suited for probing confined active matter. Using GUVs as soft containers, we encapsulate single bacteria and quantify their positional statistics through the radial probability of finding a bacterium at a given distance from the vesicle boundary. The resulting distribution shows a robust bi-exponential structure, with a steep decay near the membrane followed by a slower decay that approaches an interior plateau. The characteristic length scales exhibit a clear dependence on the vesicle radius. Using both Fokker–Planck analysis and computer simulations, we show that the short decay length is set by translational diffusion, whereas the long decay length arises from the combined effects of rotational diffusivity and self-propulsion.