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Swimming on a sphere

Active-matter dynamics on curved manifolds

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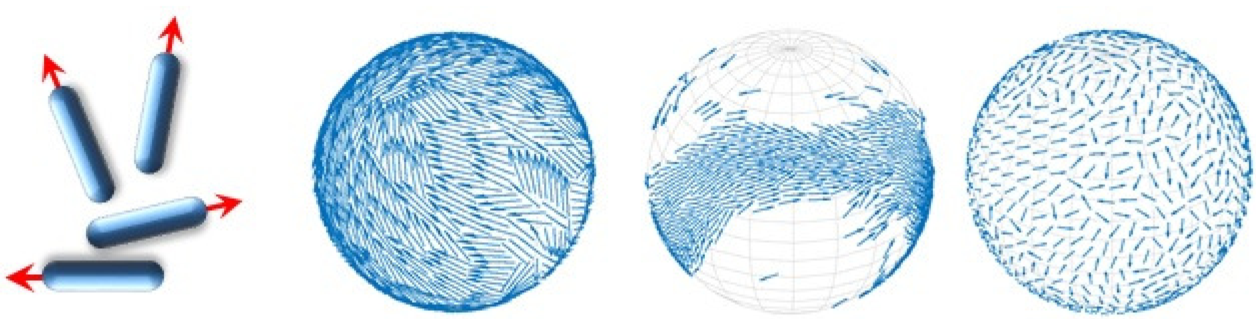

There is currently a strongly growing interest in *active matter* systems, whose constituent agents can move autonomously through the consumption of energy. Examples in nature include bird flocks, bacterial colonies, and the cytoskeleton, but artificial self-propelled particles have also recently become available. The energy dissipation at the single-particle level leads to an intrinsically out-of-equilibrium state, resulting in complex self-organizing behavior that defies the laws of conventional equilibrium statistical physics. Most studies so far, however, have focused on the dynamics in two-dimensional (2D) Euclidean space, while many natural and biomimetic systems such as droplets, vesicles, biomembranes, and cellular spheroids are characterized by a curved interface. Here we present particle-resolved computer simulations of a simple active model system composed of self-motile repulsive rods confined to a *spherical* manifold. We find that, depending on the rod length and packing density, the system can exhibit a variety of dynamical phases including swarming and distorted laning motion. Notably, for densely packed short rods, we find a novel *self-spinning glass* phase that is characterized by strong disorder and persistent collective rotation. By subsequently allowing the confining spherical manifold to swell and shrink, the active glass can be melted and revitrified through the effective change in density. We find that this 'breathing' motion of the sphere gives rise a new type of *aging dynamics*, in which the system can solidy into a more stable glass state after several breathing cycles. This is to be contrasted with the *passive*-glass scenario, which in our model system would be completely stable against swelling and shrinking. The aging behavior we observe is thus purely induced by the interplay between the geometry and activity of the system. Such activity-driven dynamics opens up new pathways for exploring and controlling the out-of-equilibrium behavior of topologically constrained active, glassy, and responsive matter.