Defects in liquid crystals act as guides in tiny oceans, directing particle traffic

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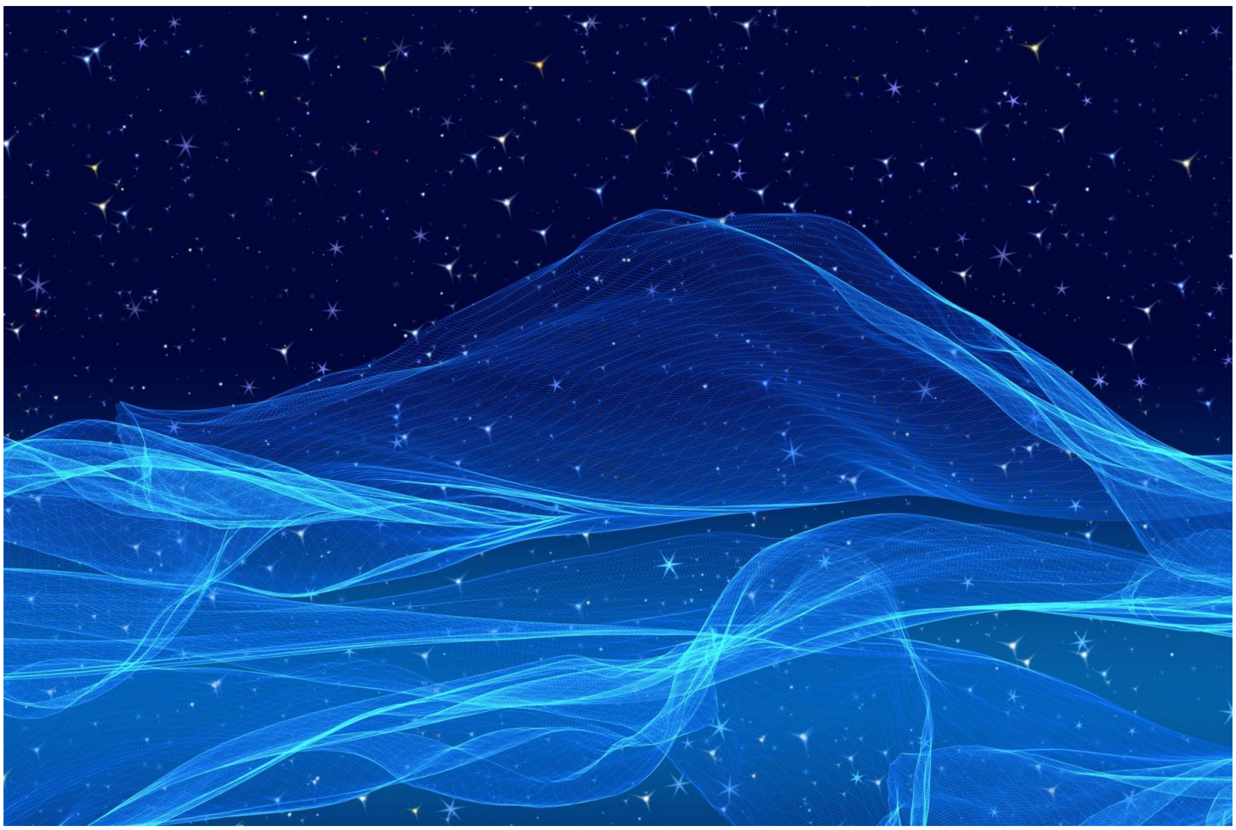

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"Living" liquid crystals combine the properties of human-made liquid crystals with features of swimming bacteria. Scientists built an accurate model of how the crystals control the motion, transport and position of swimming bacteria. The model can also simulate how other particles behave in the living crystal. Now, scientists can combine the model with on-demand synthesis and the ability to guide defects that direct the bacteria or particles. The result? This work could lead to self-healing and shape-changing materials. The materials could manage complex processes, such as producing power.

This discovery may lead to the design and synthesis of new self-healing materials by controlling defects in living crystals. Also, this work extends the tools needed to, one day, create self-regulating "machines." These machines can adapt existing components for different purposes as needed or respond to stress without stopping. Finally, this work adds to scientists' knowledge of out-of-equilibrium systems, which are involved in everything from energy generation to waste site cleanup.

Bird flocks, fish schools and self-propelling fluid mixtures that cooperatively organize and move in response to internal or external cues are all considered active matter. A new class of active matter, known as "living" liquid crystals, bridge the properties of inanimate and living materials by combining bacteria swimmers and non-toxic liquid crystals. Topological defects in these crystals play a critical role. The defects direct how the crystals are assembled and how the bacteria are transported. Managing the appearance and placement of these defects provides a useful lever for manipulating components and properties.

Scientists from Argonne National Laboratory discovered a novel concept for transporting and trapping microscopic bacteria or human-made swimmers in a liquid crystal. They developed a computational model that accurately reproduces experimental observations of the dynamics of topological defects within the liquid crystal. The model also predicts the accumulation or expulsion of swimmers from the cores of different topological defects. Fluorescent bacteria were suspended in a water-based liquid crystal. Similar to car traffic on highways, bacteria swam along certain directions parallel to the orientation of liquid crystal molecules. Topological defects in the liquid crystals effectively served as road junctions along these highways guiding and concentrating or repelling the swimmers. Directly related to the topology at the defect core, the bacteria accumulated near T-shaped defects where liquid crystal oriented streamlines (or "highways") and swimmer trajectories converge. For Y-shaped defects, streamlines are organized so that the swimmers either travel away from the core on their own or are deflected away from the core altogether. The accumulation and depletion of swimmers in the cores significantly change defect dynamics. Importantly, the model accurately correlates the reconfiguration of the liquid crystal streamlines and topological defect orientations along with changes in defect population related to the concentration of swimmers.

More information: Mikhail M. Genkin et al. Topological Defects in a Living Nematic Ensnare Swimming Bacteria, *Physical Review X* (2017). DOI: 10.1103/PhysRevX.7.011029

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