

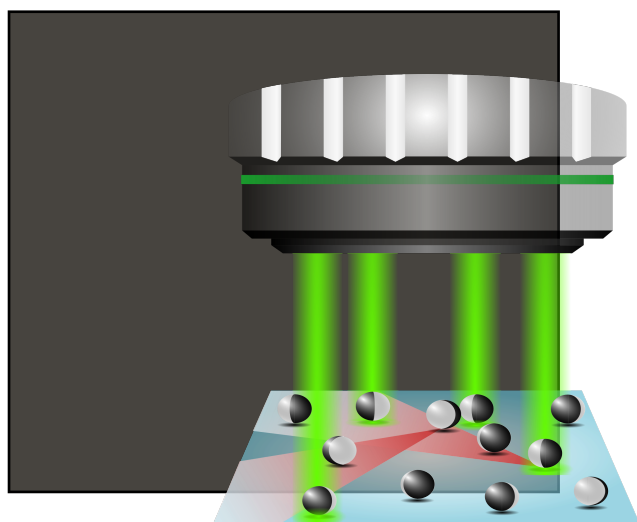
## COLLOQUIUM DFA

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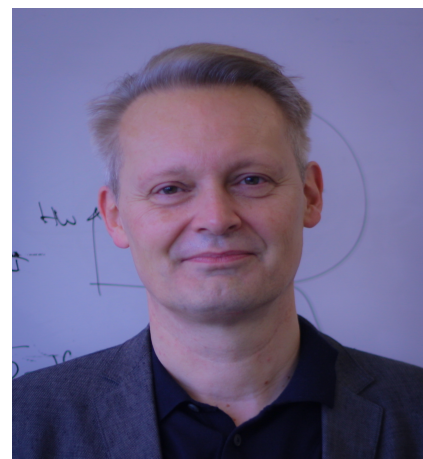
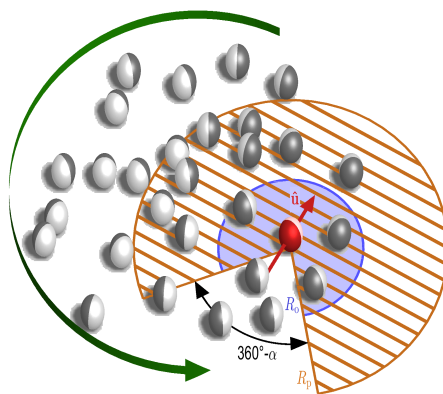
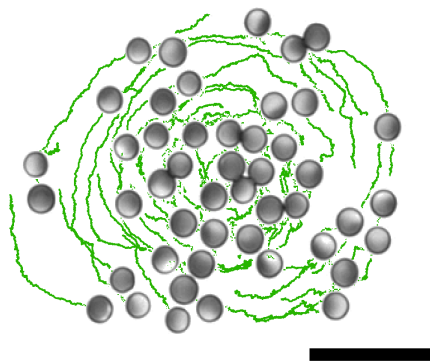
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## FORMATION OF COLLECTIVE STATES USING PROGRAMMABLE ACTIVE MATTER

Similar to living systems, self-propelled, i.e. active particles (APs) are able to arrange into collective states such as flocks or swarms. Opposed to living systems, however, currently available AP systems lack an essential feature, namely the possibility to control their motion on a single-particle level in response to their neighbours. In addition, interactions between APs are usually limited to mere physical forces opposed to much more complex social interactions dominating the response within animal groups. In our work, we present the first experimental realization of a laser-responsive AP system, which is able for controlled social interactions amongst each other. Inspired by so-called zonal models which were successful in reproducing the collective behavior of biological and social systems, our APs are able for non-reciprocal living-like interactions, i.e. they can align with neighbours, follow peers and avoid mutual collisions. Experimentally, we realize this with a feedback system where the positions and orientations of each AP are tracked in real time. This information is used to steer a laser beam to each particle such that its motion is controlled independently of each other. Exemplarily, we demonstrate the formation of cohesive swarms and rotating groups by application of relatively simple interaction rules and show their robustness against noise, misbehaving particles and the presence of obstacles. Furthermore, we provide evidence, that collective states are near a critical point as already suggested by living systems. Finally, we demonstrate how the motion of APs change in the presence of viscoelastic media, which provide the typical environment of microorganisms.

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F. Lavergne, H. Wendehenne, T. Bäuerle, and C. Bechinger, *Science* 364, 70 (2019).  
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Webinar zoom registration <https://indico.dfa.unipd.it/event/147/>  
Link YouTube <https://www.youtube.com/c/AulaRostagniUnipadovaDFA>

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