The Impact of Rotational Damping on the Collective Motion Exhibited by Systems of Self-Propelled Particles

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Collective motion has attracted increasing interest in recent years as it is observed in a wide variety of applications such as the flocking behavior of birds or self-assembling nanoparticles. A major limitation with the application of current models to non-theoretical systems is the assumption that individuals turn instantaneously. Furthermore, the lack of effective evaluation tools to fully understand the characteristics of collective motion limits their effectiveness. In this study, a new model is developed which introduces the application of rotational damping to individual turns in a system of self-propelled particles. Two novel measurements, saturation time (the time for a system to reach relative order) and influence density (the compactness of the flock), are created to analyze system behavior more effectively. This study found that damping has no impact on the universality class of the system yet has significant and counterintuitive effects on the critical point of the temperature-based phase transitions and the dynamic behavior of the system. The study examines the nature of the collective behavior exhibited by self-propelled particles and helps improve not only the fundamental understanding of the phenomenon but also the application of systems of collective motion. In particular, the results of the study promise to improve the optimization of real-world systems of collective motion. As an extension of the study, the model was adapted to explore how rotational damping affects the behavior of self-propelled particles within the laminar flow of viscous fluid, intended to represent nanoparticles used for drug delivery within the bloodstream.

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