Non-reciprocal flocking

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Non-reciprocal interactions in active matter gives rise to a multitude of fascinating phenomena among which are collective oscillatory states without intrinsic particle chirality and active turbulence. In a paradigmatic model for non-reciprocal flocking, the two species Vicsek model, we show that these two states coexist: chiral order for small flocks, and extensive spatiotemporal chaos for large flocks, both separated by a finite wavelength instability whose scale is set by the rotation radius of the chiral orbits. For system sizes larger than this length scale extensive spatiotemporal chaos unfolds, as manifested by a number of positive Lyapunov exponents that scales linearly with the system size. Moreover, it turns out that chiral quasi-long-range order can exist when density fluctuations are excluded. Finally, we discuss non-reciprocal flocking models with multiple species, one with symmetric phase shifts and one with random interactions.