Collective motion of birds: swarming dynamics with transient leadership

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The study of the collective and synchronized behaviour of animals, like bird flocks, fish schools and insect swarms, plays a central role in Mathematical Biology. Here the focus is on a model that describes the collective motion of birds in which spontaneous sudden changes of direction happen without the influence of predators. The main idea is that each bird can be a turn initiator becoming a leader whose influence acts on its nearest neighbours that are supposed to be in the followers status. Once that an agent becomes a leader it initializes a change of direction which is propagated along the whole flock. However, the leaders influence is assumed to be limited in time. Indeed, the interest is on the dynamics of *switching leaders* or *transient leadership*: each agent can change its label in time from leader to follower and vice-versa. The model can also include food sources which are visible only by the agents in the leaders status. Starting from the microscopic model, we derive a kinetic description of the agents distribution which combines an update of the positions and velocities based on binary interactions rules with a dynamic change of labels between the followers and leaders status. We show how to solve the problem numerically with a Monte Carlo algorithm to simulate the labels evolution and a Nanbu algorithm to simulate the interactions. To approximate the topological ball, we substitute the classical exhaustive search with a k-nearest neighbour search in order to reduce the computational cost from quadratic to logarithmic. We conclude by presenting different numerical tests to validate the obtained results.