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Emergence of aggregation in the swarm sphere model with adaptive coupling laws

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Abstract

We present aggregation estimates for the swarm sphere model equipped with the adaptive coupling laws on a sphere. The temporal evolution of coupling strength is determined by a feedback rule incorporating the balance between relative spatial variations and linear damping. For the analytical treatment, we employ two adaptive feedback laws, namely anti-Hebbian and Hebbian laws. For the anti-Hebbian law, we provide a sufficient framework leading to the complete aggregation in which all particles aggregate to the same position and behave like one big point cluster asymptotically. Our frameworks are given in terms of the initial positions and the coupling strengths. For the Hebbian law, we provide proper subsets of the basin of attractions for the complete aggregation and bi-polar aggregation where particles aggregate to the north pole and south pole simultaneously. We also present a uniform lp-stability of the swarm sphere model with an adaptive coupling with respect to the initial data when the complete aggregation occurs exponentially fast.