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*Equilibrium solutions to an aggregation model subject to exogenous and Newtonian endogenous forces in 2D*

We study the equilibrium solutions to an aggregation system consisting of  $N$  single-species particles and one alien particle in two-dimensional space. Starting with a discrete aggregation model subject to pairwise endogenous and exogenous forces in 2D, we derive the continuum model by introducing the continuous particle density. Throughout the study, we take the pairwise endogenous force to be Newtonian. We show that three sets of equilibrium solutions occur under applying different exogenous force exerted by the alien particle. Additionally, we analyze the stability for the annulus-like equilibrium solution with uniform density by linear perturbation off the boundaries of the domain.