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A minimal model of predator–swarm interactions

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The model of this paper:

$$\frac{dx_j}{dt} = \frac{1}{N}\sum_{k=1,k\neq j}^{N}\left(\frac{x_j - x_k}{\left|x_j - x_k\right|^2} - a\left(x_j - x_k\right)\right) + b\frac{x_j - z}{\left|x_j - z\right|^2}$$

and

$$\frac{dz}{dt} = \frac{c}{N}\sum_{k=1}^{N}\frac{x_k - z}{\left|x_k - z\right|^p}$$

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$$\dot{\mathbf{x}}_i = \frac{1}{N} \sum_{\substack{j=1 \\ j \neq i}}^{N} \left[\frac{\mathbf{x}_j - \mathbf{x}_i}{|\mathbf{x}_j - \mathbf{x}_i|} \left(1 + J \cos\left(\theta_j - \theta_i\right)\right) - \frac{\mathbf{x}_j - \mathbf{x}_i}{|\mathbf{x}_j - \mathbf{x}_i|^2} \right] - F \frac{\mathbf{x}_0 - \mathbf{x}_i}{|\mathbf{x}_0 - \mathbf{x}_i|^2}$$

$$\dot{\theta}_i = \frac{K}{N} \sum_{\substack{j=1 \\ j \neq i}}^{N} \frac{\sin\left(\theta_j - \theta_i\right)}{|\mathbf{x}_j - \mathbf{x}_i|}$$

$$\dot{\mathbf{x}}_0 = v$$