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A minimal model of predator–swarm interactions

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The model of this paper:

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

and

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

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

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

$$\dot{\mathbf{x}}_0 = \frac{c}{N} \sum_{k=1}^N \frac{\mathbf{x}_i - \mathbf{x}_0}{|\mathbf{x}_i - \mathbf{x}_0|^p}$$