Electronic Supplementary Material (ESI) for Soft Matter.

Supporting Information

S1. Numerical simulations and data analysis

Simulation code was based on C++ code of Cytosim, an Open-Source agent based simulation engine for cytoskeletal mechanics[1]. A typical simulation run with 20 asters and 7070 kinesin and 9500 dynein motors in a cell of radius 15 μm for 300 s required $\approx$ 200 minutes on a 12 core Intel machine (Xeon E5 2630) running Linux (Ubuntu 14.04) with 15.6 GB memory. The source code and parameter files have been deposited as Open-Source in a GitHub repository `https://github.com/CyCelsLab/Multi-aster-swaming`. All data analysis and plotting were performed in MATLAB R2017a (Mathworks Inc., USA). For clustering analysis, custom made Python scripts was written using scikit-learn package[2]. Heirarchical clustering (k-means) was performed using angular velocity, coherence order parameter and switching frequency as features. The silhouette score for 3 clusters of 0.58 was higher than for 2 or 4 clusters and used to determine the clusters in variable space (Figure S1). The labels of each cluster were then used to determine color classes of aster motility (Figure **??**).

Table *SI* 1 **MT parameters.** The microtubule and aster parameters used in simulations were taken from experimental measurements reported in literature, and where missing estimated.

Parameter	Description	Value	Reference
f_c	Frequency of catastrophe	0.049 (s^{-1}), varied	[3], this study
f_r	Frequency of rescue	0.0048 (s^{-1}), varied	[3], this study
v_g	Growth velocity	0.196 (μm/s)	[3]
v_s	Shrinkage velocity	0.325 (μm/s)	[3]
κ	MT bending modulus	20 (N/m^2)	[4]
Aster:			
N_a	Number of asters	20, varied	This study
N_{MT}	Number of MTs/aster	40	This study

Table *SI* 2 **Transition frequencies and MT flux rates.** The parameters of MT dynamic instability: frequency of catastrophe (f_c, s^{-1}) and frequency of rescue (f_r, s^{-1}) was varied to obtain different MT flux rates (J) at constant value of growth velocity (v_g = 0.196 μm/s), shrinkage velocity (v_s = 0.325 μm/s) and mean MT length (L_{MT} = 4.25 μm). The values were reported previously in[3,5].

f_c (s^{-1})	f_r (s^{-1})	J (μm/s)
Stabilized:		
None	None	0
Dynamic:		
20.2683	33.5317	-0.0003
2.0527	3.3273	-0.0028
0.2312	0.3068	-0.0279
0.049	0.0048	-0.2785

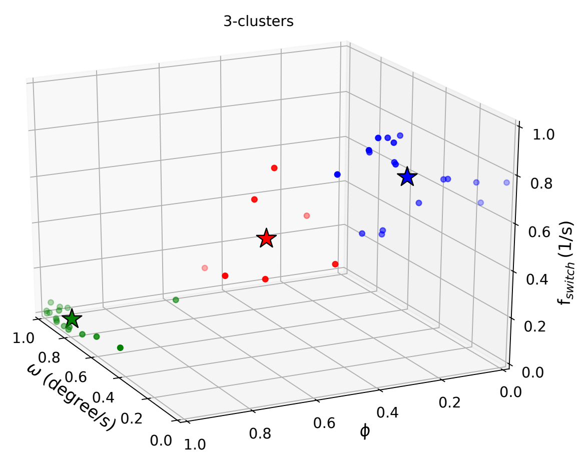
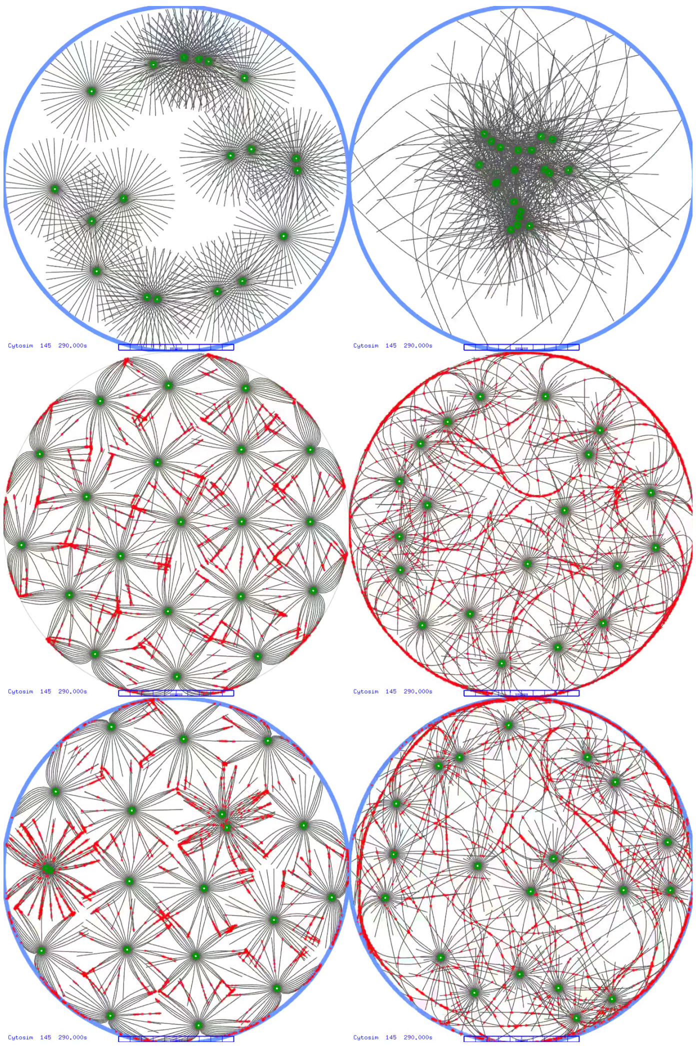


Figure S1 **Clusters of motility patterns for varying number of motors per aster and degree of uniformity at the cortex.** The parameter space for varying aster density and dynein diffusion coefficient was segregated into clusters using k-means clustering based on the measures of average angular velocity (ω), coherence in rotation (ϕ_c) and frequency of switching (f_{switch}). The circles correspond to points in the parameter space and color represents the clusters: *(green)* sustained, *(red)* coherent and persistent rotation and *(blue)* for coherent rotation with variable persistence and a lack of sustained rotation . The 'stars' indicate the centroid of the clusters. Cell size R = 11 μm, cortical dynein density = 100 motors/μm and cytoplasmic kinesin-5 density = 10 motors/μm^2.



Video SV1 The effect of *(top row)* cortical force generators, *(mid-row)* kinesin complexes and *(bottom row)* both kinds of motors on MT asters with the two columns simulating MTs lengths as *(left)* fixed *(right)* dynamically unstable. The video corresponds to results depicted in Figure 1. Time is 300 s, $N_a = 20$, $\rho_d = 100$ motors/μm, $\rho_k = 10$ motors/μm^2, J = 0 and - 0.3 μm/s for stabilized and dynamic MTs.

Notes and references

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3 C. A. Athale, A. Dinarina, M. Mora-Coral, C. Pugieux, F. Nedelec and E. Karsenti, *Science*, 2008, **322**, 1243–1247.

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