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Assembly and control of large microtubule complexes[1] KIRILL KOROLEV, Boston University, KEISUKE ISHIHARA, Max Planck Institute for the Physics of Complex Systems, TIMOTHY MITCHISON, Harvard Medical School
— Motility, division, and other cellular processes require rapid assembly and disassembly of microtubule structures. We report a new mechanism for the formation of asters, radial microtubule complexes found in very large cells. The standard model of aster growth assumes elongation of a fixed number of microtubules originating from the centrosomes. However, aster morphology in this model does not scale with cell size, and we found evidence for microtubule nucleation away from centrosomes. By combining polymerization dynamics and auto-catalytic nucleation of microtubules, we developed a new biophysical model of aster growth. The model predicts an explosive transition from an aster with a steady-state radius to one that expands as a travelling wave. At the transition, microtubule density increases continuously, but aster growth rate discontinuously jumps to a nonzero value. We tested our model with biochemical perturbations in egg extract and confirmed main theoretical predictions including the jump in the growth rate. Our results show that asters can grow even though individual microtubules are short and unstable. The dynamic balance between microtubule collapse and nucleation could be a general framework for the assembly and control of large microtubule complexes.

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