Unexpected results from *in vitro* reconstitution and simulations of dynein driven single microtubule oscillations

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Abstract

Single molecule approaches to molecular motors have revealed many aspects of these fascinating mechano-chemical enzymes. However the cellular function of motors motors is in their collective. In previous work, a universal scaling law was derived from spiralling actin filaments pinned at one end and driven by a sheet of myosins, in a 'gliding assay'. The scaling theory is based on the relation between a semi-flexible polymer with a pinning site with rotational degrees of freedom, driven by collective transport by molecular motors and experiments. Both actin-myosin and kinesin-microtubule systems were seen to agree with scaling theory. However, the effect of microtubule length and the effect on frequency of the spiralling free end were missing. We reconstitute a gliding assay with a pinned plus-end driven by cytoplasmic yeast dyneins in a 'gliding assay' and reconstitute such spiralling patterns with spiral radius of the order of few micrometers, much smaller than the persistence length. Consistent with the results for the actin–myosin system, we find the spiral radius scales with force density as $r \sim f^{-1/3}$, confirming the universality of the relation. However, we find that the frequency that was predicted to scale as $\nu \sim f^{4/3}$, is contradicted by experiments. We also examine the spiral size scaling with microtubule length and find a deviation from the simple expectation. The only explanation for our data is a persistence length that increases with filament length. Our theory and simulations can explain *in vitro* data and provide deeper insights into intrinsic mechanics of microtubules and collective force generation of motors.