Title:	Active phase fluctuations in the beat of isolated chlamydomonas axonemes
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Abstract:	Cilia and eukaryotic flagella are powered by dynein motors in order to generate periodic beat patterns. Earlier studies have shown the presence of active fluctuations in the flagellar beat arising out of the small number fluctuations in the collective dynamics of the molecu- lar motors that drive the beat. A theoretical model of the flagellum as a system of coupled motors predicts that the fluctuations measured in terms of the quality factor Q of the oscil- lations would scale with N, the number of motors. In this project we use in situ reactivated axonemes, the mechanical core of the flagellum isolated from Chlamydomonas, as our model system. Isolated axonemes beat in the pres- ence of ATP to produce a waveform similar to intact cilia attached to a Chlamydomonas cell. We present a protocol to partially remove molecular motors from axonemes and reactivate them, allowing for the first study of the relation between beat parameters and the motor number N in Chlamydomonas axonemes. The phase fluctuations in the waveform of axonemes are characterized under variation of two different control parameters: the ATP concentration used for reactivation, and number of motors N. We experimentally infer scaling relations for the beat frequency ω 0 , mean beat amplitude A, phase diffusion coefficient D 0 , and the quality factor Q. We demonstrate that the quality factor Q does indeed scale with N as predicted. Our results also shed insight into the mod- elling of the flagellar beat as a noisy Hopf bifurcation and highlight limitations of existing mathematical models.
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