Abstract Submitted
for the DFD14 Meeting of
The American Physical Society

What makes cilia beat? ASHOK SANGANI, KENNETH FOSTER, Syracuse University — There have been numerous attempts at understanding the mechanism responsible for producing steady beat in cilia that propel eukaryotic cells. The core structure of a cilium, known as the axoneme, consists of nine microtubules doublet surrounding a central pair of microtubules. The dynein motors on the doublets generate active shear forces that are responsible for relative sliding and bending of the cilium. Several theories have been put forward over the last sixty years but none are supported through a careful analysis of the ciliary beating. We have combined the methods of slender body theory and multipole expansions – both developed by Professor Acrivos and his students – to analyze in detail the hydrodynamics of ciliary beating in ten different cases. The analysis is used to infer the internal dynamics of cilia and, in particular, the active forces generated by the dynein motors along the length of cilia. We find that the properties of the axoneme vary along the length of a cilium. In the central region, the active forces generated are primarily dependent on the rate of sliding of the microtubules. This region therefore appears to be optimized to propagate a wave down the length of the cilium. The proximal region near the cell body appears more complex and may be suitable for creating waves. These conclusions from the hydrodynamic analysis are consistent with a recent study that reports different structures of the axoneme in these two regions. The detailed comparison with various theories of axoneme dynamics/ collective behavior of molecular motors show that none of the existing theories are adequate for predicting the correct active moments generated so that the mechanism for ciliary beating still remains unresolved.

Ashok Sangani
Syracuse University

Date submitted: 28 Jul 2014 Electronic form version 1.4