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Large-scale Synchronization in Carpets of Micro-rotors ANUP KANALE, HANLIANG GUO, Aerospace & Mechanical Engineering, University of Southern California, Los Angeles, CA 90089-1191, WEN YAN, Center for Computational Biology, Flatiron Institute, Simons Foundation, New York 10010, EVA KANSO, Aerospace & Mechanical Engineering, University of Southern California, Los Angeles, CA 90089-1191 — Motile cilia are ubiquitous in nature, and have a critical role in biological locomotion and fluid transport. They often beat in an orchestrated wavelike fashion, and theoretical evidence suggests that this coordinated motion could arise from hydrodynamic interactions. Models based on bead-spring oscillators were used to examine the interaction between pairs of cilia, focusing on in-phase or anti-phase synchrony, while models of hydrodynamically-coupled elastic filaments looked at metachronal coordination in large but finite numbers of interacting cilia. The latter models reproduce metachronal wave coordination, but they are not readily amenable to analysis and parametric studies that highlight the origin of the instabilities that lead to wave propagations and wavelength selection. Here, we use a known model in which each cilium is represented by a rigid sphere moving along a circular trajectory close to a wall, hence the term rotor. The rotor is driven by a cilia-inspired force profile. We generalize this model to a doubly-periodic array of rotors, assuming small distance to the bounding wall, and employ Ewald summation techniques to solve for the flow field. Our goal is to examine the conditions that give rise to stable metachronal waves and their associated wavelength.

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