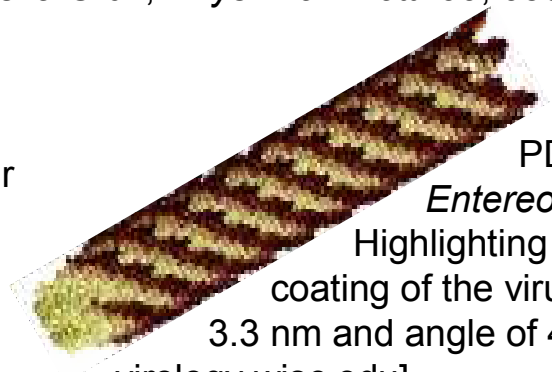
Spontaneous chirality via long-range electrostatic forces

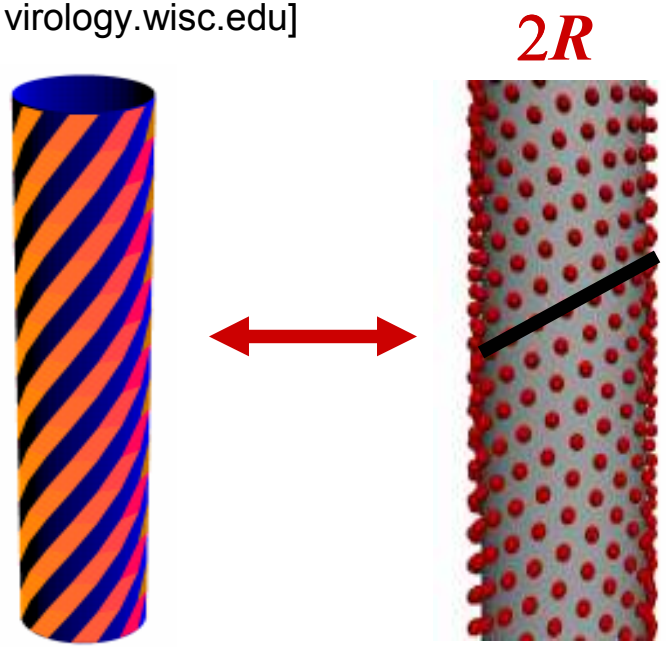
This work was supported in part by the NSF Grant No. DMR-0414446

K. L. Kohlstedt, F. J. Solis, G. Vernizzi and M. Olvera de la Cruz, *Phys. Rev. Lett*. 99, 030602 (2007).

•Louis Pasteur in 1987 stated that life was a function of the asymmetry of the universe [1]. Most biological molecules and assemblies are indeed asymmetric; resultant of the physical forces which mediate molecular interaction. An important biological assembly, helical structures, forms a majority of time in biological environments and the prevalence of this structure is without a solid theoretical explanation [2]. A property of helical structures is their chirality or breaking of mirror symmetry. Our work offers a possible explanation of the foundation of chirality in biomolecular assemblies. We show that electrostatics is responsible for nanoscale architectures forming chiral patterns. An understanding of a prevalent feature, like chirality, can lead to methods to control structures such as viruses. Controlling features of self-organized nanoscale architectures, especially those of viral size and shape, has eluded chemists and engineers for decades. Using simply electrostatic forces, which have isotropic interactions, we are able to show the formation of ribbon-like helical (chiral) patterns on the surface of cylindrical fibers. Furthermore, we have shown with straightforward tuning of the electrostatic interaction strength, via the concentration of ions, provides a mechanism to control the surface pattern of virus-like fiber. Our work paves the foundation for a new understanding into the fundamental forces that are directing nanoscale pattern formation in biological systems such as viruses.



PDB image of *Entereobacteria phage fd* Highlighting the helical protein coating of the virus with pitch of 3.3 nm and angle of 41° [2tmv from virology.wisc.edu]



Helical ion distributions showing chiral structures.

[1] Pasteur L., C. R. Acad. Sci., Paris, June 1, 1874

[2] Dogic, V. and Fraden S. *Ordered Phases of Filamentous Viruses*. Current Opinion in Colloid and Interface Science, 2005