Volvox *barberi* likely use weak forces to aggregate into optimally packed two-dimensional flocks

Ravi Nicholas Balasubramanian
Harriton High School, Rosemont, PA 19010

Abstract:
Volvox barberi are multicellular protists forming colonies of 10000-50000 cells. I established that typical colonies have diameters varying ten-fold from ~50 to ~500 microns, drawn from a log-normal distribution. I measured swimming speeds up to 600 microns/second, making this one of the fastest swimming Volvox species. I showed that *barberi* aggregates actively into "flocks" of 2 to more than 100 colonies, which move and rotate collectively at high speeds. The *Volvox* centers in flocks form a packed, irregular lattice. I hypothesized that the *Volvox* were dynamically finding the optimal packing for their size distribution. To test this, I built molecular dynamics simulations of spherical particles with a log-normal diameter distribution (matching the *Volvox*), and a weak long-range attractive force with strong local repulsion (to model mutual exclusion of colonies). Such "soft-spheres" are known to form random close-packed configurations that pack nearly optimally. I found that the lattice angle distribution in these close-packed configurations was identical to that of *Volvox* flocks. This suggests that the *Volvox* achieve random optimal packing by exerting weak, long-range attractive forces on one another. Using a dye tracer, I show that the Volvox create water currents as the colonies rotate by beating their flagella, and that these currents can both attract and repulse the fluid over distances ranging over many Volvox diameters. This provides a likely source for the forces leading to flocking.