Emergence of a stable nonequilibrium bacteria-phage collective state from scale-dependent feedback

Hong-Yan Shih

A key question in astrobiology is to understand the timescale and evolutionary trajectory of the microbial communities that influence the development of Earth's environment and the biosphere. In particular, what accounts for the stability, co-evolution and diversity of microbial and viral ecosystems? We show that predator-prey dynamics can lead to an emergent collective state between bacteria and their phage, but only if both are able to utilize genes that are horizontally transferred. We apply this model to one of the world's most abundant organisms: the marine cyanobacteria Prochlorococcus spp. whose phages carry photosystem II genes that benefit both the bacteria and the phage. Our results account for the emergence of ecotypes and show that non-equilibrium antagonistic interactions between organisms, on scales ranging from genomes to the environment, can drive the evolution of ecosystem stability and diversity.