Clustering in a polydisperse phytoplankton population

Matteo Borgnino[1], Filippo De Lillo[1] and Guido Boffetta[1]

[1]Department of Physics and INFN, University of Turin, Italy

Phytoplankton's patchiness has profound effects on the ecology of the oceans [1]. It plays a fundamental role in microorganisms populations composition and it also modulates the encounter rate, the predation and the reproduction [**?**]. Clustering can occur over very different scales, from planetary to the microscale; in this work we are interested in the small scale clustering. It is due mainly to the combined effect of turbulence and phytoplankton motility [3]. Indeed it has been found that motile microorganisms are more patchy that non-motile [4].

Several species of motile phytoplankton are able to swim upward guided by a stabilizing torque arising from an unbalance distribution of the mass in the cell. The latter kind of motion is called gyrotaxis; different works have showed how this type of motility, combined with the presence of a flow (laminar, horizontal shear, turbulent), generates strongly inhomogeneous distributions[3, 5, 6, 7].

For these reasons the current study focuses on the effect of polydispersity (or variation) of the swimming parameter in a gyrotactic phytoplankton population trasported by a turbulent flow.

At first we investigate the case of a bimodal distribution, composed by two different species; then we consider a more realistic case , where the swimming parameter is Gaussian-distributed within the population. By means of extensive numerical simulations, we find that the variety of the population introduces a characteristic scale R^* in its spatial distribution, that depends on the dispersion of the population. At scales smaller than R^* the swimmers are homogeneously distributed, while at larger scales an inhomogeneous distribution is observed with a fractal dimension. Our numerical results, which extend recent findings for a monodisperse population, indicate that in principle it is possible to observe small scale, fractal clustering in a experiment with gyrotactic cells.

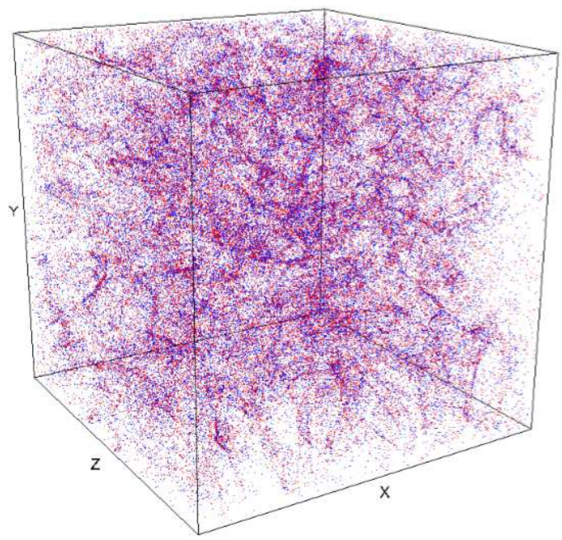

Figure 1: Distribution of the positions of two species of swimmers with two different swimming parameter (blue and red) in a turbulent flow.

[1] W. R. G. Williams and M. J. Follows, *Ocean dynamics and the carbon cycle: Principles and mechanisms* (Cambridge Univ. Press, 2011).

[2] T. Kiørboe, *A mechanistic approach to plankton ecology* (Princeton Univ. Press., 2008).

[3] W. M. Durham, E. Climent, M. Barry, F. De Lillo, G. Boffetta, M. Cencini and R. Stocker, Nature Communications, **4**, 2148 (2013).

[4] L.T. Mouritsen and K. Richardson, J. Plank Res., **25**, 783-797 (2003).

[5] J.O.Kessler, Nature, **313**, 218 (1985)

[6] W.M. Durham and R. Stocker, Annu. Rev. Mar. Sci., **4**, 177 (2012)

[7] F. Santamaria, F. De Lillo, M. Cencini and G. Boffetta, Phys. Fluids, **26**, 111901 (2014)