Structure and dynamics of epithelial cell monolayers

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Abstract
The description and the understanding of the collective behaviour of large assemblies of cells represent a great challenge from a physicist's point of view. In fact, the active nature of the constituents as well as the complexity and diversity of the involved interactions, complicate the use of familiar tools and concepts borrowed from equilibrium statistical mechanics. Nevertheless, in recent years some intriguing analogies have been drawn between the coarse-grained structure and dynamics of multicellular assemblies and relatively simple condensed matter systems, such as for instance a supercooled fluid approaching the glass transition [1]. In this work, we experimentally investigate the connection between spatial organization and collective motility patterns emerging in epithelial cell monolayers. Differential Dynamic Microscopy [2] analysis of time-lapse movies obtained during a timeframe comprising 48 hours reveals that the overall dynamics of the cells exhibits a transition from ballistic-like, persistent motion at short stage to a diffusive-like, disordered behaviour at the late stages of the investigated period. We find that these overall dynamics are altered by structural interactions that we determine quantitatively by calculating the structure factor S(q) of the cell monolayer, where q is the wave-vector of the density fluctuations in Fourier space. The structure factor, which for large q (length scales smaller than the average cell size) is reminiscent of that of a hard-disk system, exhibits for smaller q a growth that is indicative of 'giant' density fluctuations with amplitude much larger than expected from equilibrium statistical mechanics. This remarkable connection between the structural properties of the monolayer and its dynamics, in which density fluctuations with a wave vector q corresponding to a maximum in the structure factor decay slowly, is the analogue for active, non-equilibrium materials of the so-called De Gennes narrowing [3] observed in inert liquids and soft materials at equilibrium. This analogy is however very surprising in view of the fact that in equilibrium this slowing down for density fluctuations at the structural peak is attributed to the low free energy cost of such fluctuations, an argument that cannot be straightforwardly extended to non-equilibrium cases.

References
[1] T.E. Angelini, E. Hannezo, X. Trepat, M. Marquez, J.J. Fredberg, D.A. Weitz, PNAS, **108**, (2011) 4717
[2] R. Cerbino, V. Trappe Phys. Rev. Lett. **100**, (2008) 188102; F. Giavazzi, R. Cerbino J. Opt. **16**, (2014) 083001.
[3] P. G. de Gennes, Physica A **25**, (1959) 825

Figures

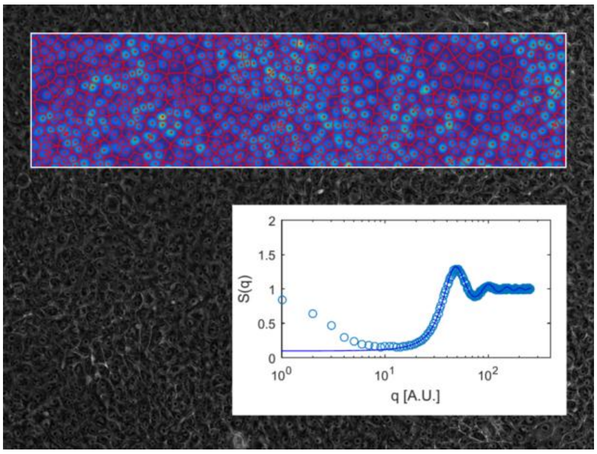

Figure 1: Composite figure containing an image of a cell monolayer at large density, a Voronoi tessellation of one portion of it, and the structure factor S(q) of the monolayer.