Hydrodynamic instabilities, waves and turbulence in spreading epithelia

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In recent years a great deal of attention has been focused on the modelling and understanding of freely expanding epithelial monolayers, as a model system to study morphogenesis, tissue repairing or cancer invasion. These cellular systems exhibit a rich repertoire of dynamical behaviours. In particular, some puzzling observations have revealed the existence of elastic waves at time scales of several hours where one would expect a fluid-like behaviour [1]. In our study, we show that these observations can be conciliated through a minimal model of a thin active gel by introducing two sources of activity: traction forces with the environment and intercellular contractile stresses. Our physical model harbours a new periodic oscillatory instability controlled by the cell-sbstrate interaction. The anomalous phase of the stress-strain rate oscillations is not universal, unlike Newtonian fluids, but depends on the material properties of tissues. Near criticality, the system admits a reduced description in the terms of the Complex Ginzburg-Landau equation, for which we derived analytically the mapping, providing a complete characterisation of the dynamical states of the system, which are comprised between coherent nonlinear waves to turbulent states. We compare these results with recent experimental observations [1-3] on these cellular system and bring to light novel predictions.

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