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Forum de Physique Statistique @ ENS

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Titre : *Irreversibility and active matter : a geometric insight*

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Résumé : *Active systems are made up of elementary agents that are able to self-propel, "microscopically" driving the system out-of-equilibrium by doing so. The collective behaviors of such systems—of which collective motion or motility induced phase separation (MIPS) are emblematic instances—are best described by field theories. At this large-scale long-time level, the irreversibility of these systems can be subtle to capture.*

To fill this gap, we introduce a functional generalization of the exterior derivative, which is itself a generalization of the curl operator to (finite) dimensions higher than 3. This functional exterior derivative allows to associate to a field dynamics a functional "vorticity", or "cycle affinity". As soon as this vorticity vanishes time-reversal symmetry (TRS) is effectively restored at the macroscopic scale, which implies that all the machinery of equilibrium statistical field theory can be applied to determine e.g. the phase diagram. Whenever the dynamics of the system is macroscopically irreversible, the functional vorticity is not identically zero and provides a valuable insight on the way TRS is broken, from the shape of the stationary probability current to the counterparts of this current in the physical space. For instance, in the case of the active model B – that is a minimal field theoretic description of MIPS – the latter correspond to the permanent excitation of anisotropic, propagating modes that are localized at the liquid-gas interface. Furthermore, for stochastic vector fields over a one-dimensional space, we exhibit a basis of functional vorticities, the elements of which can be seen as independent sources of irreversibility on which the entropy production rate can be decomposed. In addition, these basis elements allow classifying the potential out-of-equilibrium behaviours the field theory can display.