M2 internship in Soft Matter and Statistical Physics 2027
Possibility of continuation into a funded PhD

How activity shapes transport and mechanics in crowded cellular matter

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Keywords: Soft matter, statistical physics, active matter, nonequilibrium fluctuations, anomalous transport, glassy dynamics, microrheology, particle tracking, stochastic processes.

Context: The interior of a cell is a striking example of an active soft material: it is dense, heterogeneous, viscoelastic, and continuously driven far from equilibrium by internal energy-consuming processes. From a physics perspective, this activity can fluidize an otherwise glassy material and strongly enhance tracer motion. Yet we still lack a quantitative description of how energy injection and packing control fluctuations, transport, and mechanical response. The ANR-funded project, **ActiveCyt**, addresses this problem by combining controlled experiments with statistical-physics modeling.

M2 project: The intern will use living yeast as a robust experimental realization of a crowded, active material. We will tune packing by controlled changes in the surrounding solution and vary the level of internal activity, then follow tracer particles spanning nanometer to micron scales. The main task will be to extract displacement distributions, correlation functions, power spectra, and effective mechanical response from the resulting trajectories. Depending on the student's interests, the project can emphasize high-speed microscopy and optical-tweezer measurements, data analysis, or stochastic modeling. The central physics question is how nonequilibrium forcing and crowding combine to produce glassy, diffusive, hopping, or directed transport. Established experimental protocols and training in the model system will be provided.

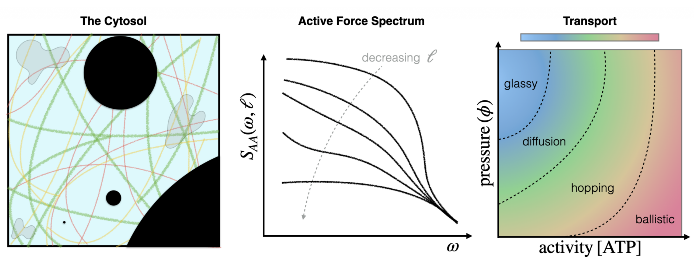

Figure 1: ActiveCyt treats the cell interior as a crowded active material. Tracer probes of different sizes measure scale- and frequency-dependent force fluctuations, $S_{\mathrm{AA}}(\omega, \ell)$. Together, packing ϕ and energy input set the observed transport regime, from glass-like confinement and diffusion to hopping and directed motion.

Profile: We seek a curious and motivated M2 student in physics or a related quantitative field, particularly someone interested in soft matter, statistical physics, or nonequilibrium systems. Experience with data analysis and programming (Python, Matlab, or equivalent) is desirable; experience with microscopy, particle tracking, or stochastic modeling is a plus. **No prior background in biology is required.** The project is designed for a physicist who would like to study fundamental soft-matter questions using a living system as the experimental platform.

Practical information and PhD opportunity: The internship will take place primarily at the LPT and CBI in Toulouse for ∼6 months, with a start in January 2027. It will also include close collaboration with Morgan Delarue at LAAS. The internship is funded according to the standard French M2 internship allowance. Funding is also available for a three-year PhD that will extend this research within **ActiveCyt**. An excellent intern interested in continuing the project may therefore be considered for the funded PhD, subject to mutual interest and the formal doctoral recruitment process. To apply, please send a CV, a brief cover letter describing your interests and relevant experience, and recent academic transcripts to W. Ahmed (wylie.ahmed@utoulouse.fr).

Selected references:

1. B. R. Parry et al., "The bacterial cytoplasm has glass-like properties and is fluidized by metabolic activity," *Cell* (2014).
2. W. W. Ahmed et al., "Active mechanics reveal molecular-scale force kinetics in living oocytes," *Biophysical Journal* (2018).
3. M. Delarue et al., "mTORC1 controls phase separation and the biophysical properties of the cytoplasm by tuning crowding," *Cell* (2018).
4. T. M. Muenker et al., "Accessing activity and viscoelastic properties of artificial and living systems from passive measurement," *Nature Materials* (2024).