Abstracts

Thursday 18th September

Raphaël Voituriez: *First-passage times of random walks and transcription kinetics*

How long does it take a "searcher" to reach a "target" for the first time? This first-passage time is a key quantity for evaluating the kinetics of various processes, and in particular chemical reactions involving "small" numbers of particles. A striking example is given by gene transcription, where specific proteins search for target sequences on DNA.
I will present asymptotic results which enable the evaluation of the distribution of the first-passage time to a target site for a wide range of random processes in confined domains. This approach quantifies explicitly the amplitude of fluctuations of the first-passage time and reveals its general dependence on the geometry of the problem, which can become a key parameter that controls the kinetics. I will show how these results apply to reactions involving "small" numbers of particles, and highlight their implications in transcription kinetics.

David Holcman : *Extracting features from Superresolution data, based on stochastic analysis and simulations in empirical domains*

A large amount of data are now generated in molecular and cellular biology using recent techniques such as superresolution microscopy for trajectories of single molecular particles. How to make sense of such massive information and extract data?
The goal of this presentation is to present physical modeling and recent mathematical analysis, used to sort data and predict neuronal function. The analysis relies on stochastic equations and partial differential equations of the models.

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Friday 19th September

Jacques Pécréaux: *Positional fluctuations of the mitotic spindle poles reveal cell division mechanics: a study by image processing and Fourier analysis*

How does cell perform division in a so robust and faithful fashion? To address this question, we aim to supplement the structural, biochemical and molecular cell biology approaches of cell division by studying its dynamics related to mechanical aspects. Our lab combines experiments using the one-cell embryo of nematode C. elegans — a classic model organism of (asymmetric) cell division —, analysis through image and signal processing and modeling based on stochastic differential equations.

We were particularly interested in the mechanism that maintains the mitotic spindle in cell center during metaphase and in spindle mechanics in connection with chromosome attachment defect corrections. To do so, we accurately tracked spindle poles (~15 nm accuracy) at high frame rate (~30 frames per seconds) to reveal the fast random micro-movements superimposed to slow trend.
A bandpass filtering using signal decomposition algorithms enabled us to quantify centering stability and thus to identify some players involved in maintaining the spindle in cell center. To decipher the mechanism, we extracted the fluctuation spectra of the poles position through a careful Fourier analysis and fitted cell-scale (macroscopic) models, designed in link with microscopic details.
In contrast to the centering mechanism, the spindle is in constant evolution during its elongation; we improved our method to enable us to measure the variations of the model parameters over time. In both projects, gene candidate approaches were performed to identify putative players at molecular (microscopic) scale.

Investigating the fluctuations enabled us to probe the mechanisms close to the physiological conditions with a minimally perturbative approach. Such a study paves the way to understand the emergence of properties like the robustness coming from the network of molecular players.

EA Gaffney: *Exploring The Mechanics Of Swimming Flagellates*

Mammalian spermotozoa motility is a subject of growing importance, due to rising human infertility and the possibility of improving animal breeding for livestock and conservation, while understanding how bacterial motility contributes to colonisation and biofilm initiation is of fundamental concern in numerous fields. Fluid and filament mechanics offers many opportunities to provide novel insights concerning the mechanics of such swimming cells. Examples of the information that can be extracted by combining imaging and continuum mechanics will be highlighted together with studies of how mechanical effects can influence cell behaviour especially near surfaces.
