Many cellular processes, such as cell division, cell polarity and motility require proteins to be precisely positioned within the cell. The same is often true of chromosomal loci and, in particular, the chromosomal origin of replication. In this talk, I will present recent results on the positioning of the E. coli condensin MukBEF and its role in positioning chromosomal origins.

MukBEF forms dynamic nucleoid-associated clusters at middle cell that split during cell growth and move to opposite quarter positions. We developed a model to explain this behaviour based on a phase-locked stochastic Turing pattern. A single peak in the concentration is always positioned at the midpoint of the cell, while two peaks are positioned at the quarter positions. Growth results in peak-splitting and pattern doubling. We argue that the model explains the regular positioning of MukBEF and that it provides an attractive mechanism for the self-positioning of dynamic protein clusters in other systems.

Like many other bacteria, the chromosomal origin of replication in E. coli is dynamically positioned throughout the cell cycle. Initially maintained at mid-cell, where replication occurs, origins are subsequently partitioned to opposite quarter positions. MukBEF, which is required for correct chromosome compaction and organisation, has been implicated in this behaviour but the mode of action is unknown. We build on our self-organising model for the positioning of MukBEF to propose an explanation for the positioning and partitioning of origins. We find that specific loading of MukBEF onto the chromosome within the origin region, results in a non-trivial feedback between the self-organising MukBEF gradient and the origins, leading to accurate positioning and partitioning as an emergent property. We compare the model to quantitative experimental data of origin dynamics and their colocalisation with MukBEF clusters and find excellent agreement. Overall, the model suggests that MukBEF and origins act together as a self-organising system for chromosome segregation and introduces protein self-organisation as an important consideration for future studies of chromosome dynamics.