Master 2: ***International Centre for Fundamental Physics***
INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique des Solides (LPS)
CNRS identification code: UMR 8502
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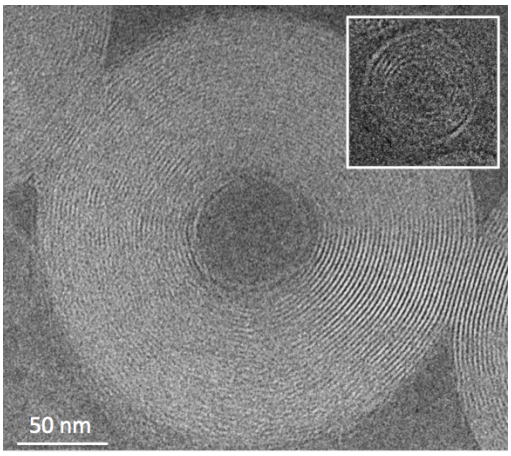
Internship location: LPS, Bât. 510, Université Paris-Sud, Orsay

Thesis possibility after internship: YES
Funding: NO (demande en cours) If YES, which type of funding:

Competition between helicity and hexagonal order in condensed biological polymers: Order & disorder in DNA toroids analysed by cryo-electron microscopy

Polymer random coils in good solvents collapse to compact globules in poor solvent. Among these, semi-flexible polyelectrolytes, like DNA, condense into toroids in the presence of multivalent cations, crowding agents or basic proteins. These striking objects have intrigued biophysicists and physicists, both experimentalists and theoreticians, for more than 30 years. DNA strands within toroids are packed into a hexagonal lattice. But we do not dispose of a global understanding of their structure as well as its relationship with the mechanisms of their formation. Topological constraints imply defects. DNA helicity induces twist that competes with the parallelism of hexagonal order. In addition, local disorder has been postulated.



DNA toroids formed in the presence of spermine (4+) observed by cryoEM. Upon DNA ejection from phages, we generate either giant multimolecular toroids (templated around capsids), or small monomolecular ones (confined into capsids).

The aim of the internship (ideally followed by a PhD thesis) will be to determine the 3D organisation of the DNA chain(s) forming a toroid. Coexistence between ordered and disordered regions, correlations between DNA double helices and topological defects will be explored.
We will use cryo-electron microscopy (cryoEM), a tool of choice to explore biological matter at (sub)nanometer resolution. We have established an experimental workflow to control the formation of DNA toroids over a wide range of size (Figure). Our lab is fully equipped for toroid preparation from phage and cryoEM 2D imaging. We also have access to cryoEM labs equipped with tomography.

This project will contribute to the understanding of DNA compaction. Toroidal forms are considered as models to help us understand genome packing in certain viruses (bacteriophages, herpes), and sperm cells where DNA is hexagonally packed. They are also being considered for applications in biotechnologies (such as gene therapy), and nanosciences. In addition, common architectures are found across many biological polymeric materials (e.g. collagen, actin, etc) where long chiral molecules order into compact hexagonal arrays.

Condensed Matter Physics: YES	Soft Matter and Biological Physics: YES
Quantum Physics: NO	Theoretical Physics: NO