Microrheology of DNA origami

DNA origami is an emerging field in nanotechnology and functional materials. It harnesses the information-encoding capability of DNA to form complex and responsive 3D shapes that may be used in a broad range of applications, from drug delivery to nanoelectronic circuits [1]. Origamis are traditionally studied in isolation but there is a growing interest to study the collective behaviour of dense solutions of origamis [2]. Thus, **in this project we will explore the microrheology of dense solutions DNA origamis as a function of their design.** This research direction is still at its beginnings and can uncover unprecedented ways to employ DNA origami with potentially substantial academic and industrial impact.

Rheology (from panta rhei, Heraclitus) is the study of how fluids flow and how viscous or elastic they are on certain timescales. Microrheology is a technique that allows us to probe these viscoelastic behaviours using micron-sized particles embedded in the fluid and require minute amount of material [3]. The project will start by investigating a class of structures named "chimeric" that display combinations of looped and linear DNA [4]. The simplest of such structures is a "tadpole" (Fig. 1) and has already been designed and obtained from the company which is collaborating in the project, Tilibit nanosystems.

After the initial training on origami design and preparation, you will be allowed to choose and design which origamis to investigate further. You will also be trained on Atomic Force Microscopy (AFM) and will spend at least a term in year 1 performing AFM experiments in Durham supervised by **K. Voitchovsky.** Depending on your inclination, you will also be able to train and perform large-scale molecular dynamics simulations of these complex fluids [4].

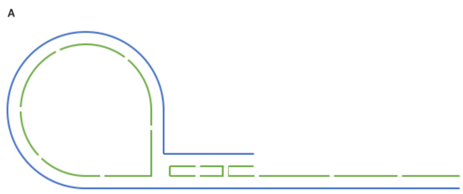

Fig. 1 - A DNA origami tadpole designed with DNA scaffold (blue strand) and DNA staples (green strands). Courtesy of Tamara Aigner, Tilibit.

[1] Seeman, N. C. & Sleiman, H. F. DNA nanotechnology. *Nat. Rev. Mater.* **3**, 1 (2017).

[2] Siavashpouri, M. *et al.* Molecular engineering of chiral colloidal liquid crystals using DNA origami. *Nat. Mater.* **16**, 849–856 (2017).

[3] Mason, T. G. Estimating the viscoelastic moduli of complex fluids using the generalized Stokes-Einstein equation. *Rheol. Acta* **39**, 371–378 (2000).

[4] Rosa, A., Smrek, J., Turner, M. S. & Michieletto, D. Threading-Induced Dynamical Transition in Tadpole-Shaped Polymers. *arxiv* 3–7 (2019).

Internship

As part of this project you will be encouraged to do a 3-months internship at Tilibit nanosystems GmbH in Munich, Germany (https://www.tilibit.com/). You will be also encouraged to spend some time in the group of Prof. Robertson-Anderson at the University of San Diego (USA) to learn active microrheology (https://home.sandiego.edu/~randerson/people.html).

More Details

In practice, you will learn (i) to work in a wet-lab and in a mixed (experimental-computational) group (ii) a range of wet-lab techniques, (iii) to quantify and critically assess your experiments via orthogonal methods/techniques (iv) a range of microscopy techniques and (v) coding for design of DNA origami, post-processing and statistical quantification. Depending on your inclination, you will also train in (i) molecular dynamics simulations and polymer models (ii) managing data and computing time. You will also have access to summer schools and fully-funded short-term-scientific-missions from the Cooperation in Science and Technology Network "EUTOPIA" (https://eutopia.unitn.eu).