Physical and biological nanofluidics

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1. Proposal

1.1 Introduction and motivation

Flows of molecules at the nanometers scale play an important role in many biological, chemical and physical systems and have important applications in the near future. Nanofluidics is a very active topic of research and attracts different fields from biology to engineering.

Ions and macromolecules are transported across lipid membranes by highly selective nanoscaled protein channels. The study of these processes and their imitation in artificial structures, fabricated by chemical synthesis or micro-fabrication, offers many opportunities for applications in ultrasensitive detection of molecules : rapid sequencing of DNA or RNA, studies of conformation (secondary structure of RNA, protein folding), or molecular interaction between proteins or between proteins and nucleic acids [1-5]. The integration of channels and pores in the nanometer micro-fluidic devices or on deposited lipid bilayers on solid surfaces leads to the creation of new bio-sensors.

Carbon nanotubes and nanoslits offer the possibility to explore new phenomenas appearing for molecular flows confined in nanometers scales. Problems like sliding on interfaces, molecular crowding are some examples.

The highly intrincate nature of the interactions in nanochannels is a major challenge in order to modelize and simulate such hydrodynamical systems. The emerging consensus in the field is that the synergy between computational, theoretical, and experimental approaches will be needed in the next few years

1.2 State of the art

The studies of these transport phenomena at the molecular scales are difficult [5, 6] and this was a real revolution when J. Kasianowicz, E. Brandin, D. Branton and D. Deamer [7] with G. Church and R. Baldarelli [8] showed that one observes directly by a very simple electrical method the passage of one single strand DNA or RNA molecule through a protein pore inserted in a bilayer lipid membrane.
This electrical method of detection is the same as the one used in the “Coulter counter” at a more macroscopic scale [9] (figure 2). In the biological context of the study of membrane proteins, it is quite close to the “patch-clamp” and “black lipid membrane” electrophysiological techniques [10-13].

Since this works, several teams in the world explore theoretically [14, 15] and experimentally the numerous applications of the transport of macromolecules in nanopores. It concerns the ultrafast sequencing of DNA and RNA[16] , the

manipulation of biological macromolecules[17, 18], the development of chemical and biological sensors[19], fundamental studies of confined polymer chains [20] and the search for new natural[21] or artificial channels made by transforming cyclic molecules[22], using carbon nanotubes[23], heavy ions track etch techniques[24] or nanofabrication techniques such as focused ion beam [25, 26] and electron beam[27].

Nevertheless, many challenges are still ahead in this field. First, the fundamental physics of the transport in nanochannels is still poorly understood (force control during the translocation, explored energetic landscape). Then, the studied channels are seen as passive objects and the idea of active biomimetic systems used to produce controlled nano-object still have to be develloped.

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Objectives

The specific aim of this discussion meeting is to bring together researcher working on the transport in nanofluidic systems both from simulation or theoretical approaches and experimentalists. These meeting intent to create collaborations between theoreticians and experimentalist, which in turn advanced the field, and put forth new problems the community needs to tackle.

1.3 **Participant List**

We propose a list of selected specialists in the field of simulation and physics of transport.

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2. Financial Support

We expect financial support to come from different sources :

CFCAM (8000 € + meeting room at IHP)
C'Nano (2000€)
Ville de Paris (2000€)
Université Paris Diderot (1000€)
Université d'Evry (2000€)
ANR Biopgrahène (2000€)

Our estimated budget is then 17 000 €