IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

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| **Project Title:** | **Diffusion of active colloidal chains through obstacles as a model for cell motility** | |
| **Project Number** | **IMURA0868** | |
| **Monash Main Supervisor** (Name, Email, Phone) | Prof. Reza Nosrati<br>reza.nosrati@monash.edu | *Full name, Email* |
| **Monash Co-supervisor(s)** (Name, Email, Phone) | Prof. Prabhakar Ranganathan<br>prabhakar.ranganathan@monash.edu | |
| **Monash Head of Dept/Centre** (Name, Email) | Prof. Chris Davies<br>chris.davies@monash.edu | *Full name, email* |
| **Monash Department:** | Mechanical & Aerospace Engineering | |
| **Monash ADGR** (Name, Email) | Prof. Emanuele Viterbo<br>Emanuele.Viterbo@monash.edu | *Full name, email* |
| **IITB Main Supervisor** (Name, Email, Phone) | Prof. Guruswamy Kumaraswamy<br>guruswamy.kumaraswamy@gmail.com | *Full name, Email* |
| **IITB Co-supervisor(s)** (Name, Email, Phone) | | *Full name, Email* |
| **IITB Head of Dept** (Name, Email, Phone) | Prof. Ravindra Gudi<br>Head.che@iitb.ac.in | *Full name, email* |
| **IITB Department**: | Chemical Engineering | |

## Research Clusters:

**Highlight which of the Academy's CLUSTERS this project will address?**
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

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|---|---|
| 1 | ***Material Science/Engineering (including Nano, Metallurgy)*** |
| 2 | *Energy, Green Chem, Chemistry, Catalysis, Reaction Eng* |
| 3 | *Math, CFD, Modelling, Manufacturing* |
| 4 | *CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control* |
| 5 | *Earth Sciences and Civil Engineering (Geo, Water, Climate)* |
| 6 | *Bio, Stem Cells, Bio Chem, Pharma, Food* |
| 7 | *Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng* |
| 8 | *HSS, Design, Management* |

## Research Themes:

**Highlight which of the Academy's Theme(s) this project will address?**
*(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

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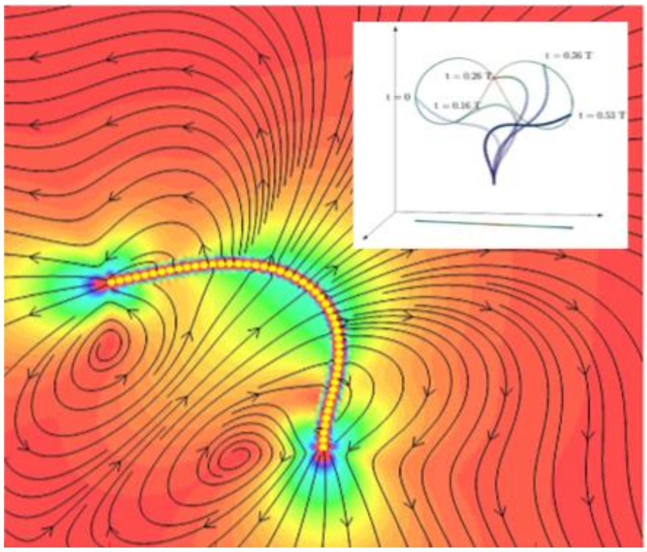
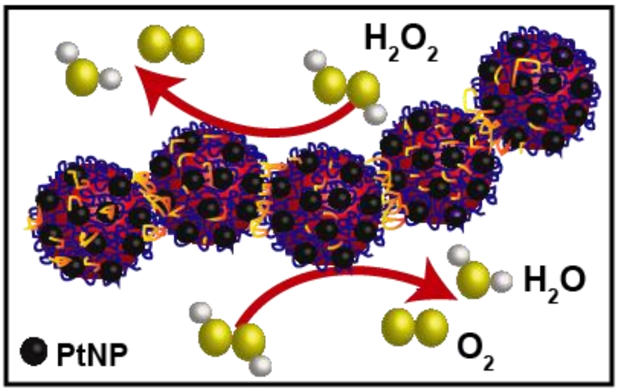
|---|---|
| *1* | *Advanced computational engineering, simulation and manufacture* |
| 2 | *Infrastructure Engineering* |
| 3 | *Clean Energy* |
| 4 | *Water* |
| 5 | ***Nanotechnology*** |
| 6 | *Biotechnology and Stem Cell Research* |
| 7 | *Humanities and social sciences* |
| 8 | Design |

**The problem:** How do the principles of hydrodynamics apply to cells navigating in confined environments? Since cells are ranging in size from microns to tens of microns, their swimming is dominated by viscosity rather than inertia, and their hydrodynamics is characterized by very low Reynolds numbers. Further, cells are out of equilibrium since they use energy from ATP hydrolysis to fuel their motions. Thus, non-equilibrium versions of the fluctuation dissipation theorem need to be invoked to understand their motion. For cells such as sperm cells that swim through highly confined environments to reach the egg, motion is additionally determined by the narrow channels that guide their motion. The motility of sperm cells has important implications for reproduction. Direct studies of the motility of cells is challenging due to experimental difficulties associated with biological variability and visualization of moving cells in their natural environment. Therefore, an experimentally tractable system that mimics cellular motility, that is reproducible, that allows tuning of the non-equilibrium energy flux and that allows accurate visualization has the potential to provide important insights into a biologically relevant problem.



*An internally driven flexible microfilament can undergo wavy motions (inset) driving complex flows in the surrounding fluid. (Image source: Laskar et al., Sci. Rep., 2013)*




*Schematic of a synthetic active colloidal chain coated with catalytic platinum nanoparticles (PtNP) that catalyze reactions at the chain surface (Image source: Biswas et. al. ACS Nano, 2017)*

**The approach:** Several researchers across the world have synthesized artificial "micromotors" – micron-sized particles that can be driven by chemical reactions. More recently, Prof. Guruswamy's group has, for the first time, created micromotor chains that exhibit enhanced diffusivities driven by active flows. The strength of these fluctuating motions can be controlled by adjusting the properties of the particles and the chemical fuel. These synthetic systems are ideal models for motile biological objects.

**The outcomes:** This Project focuses on studying the diffusion of active colloidal chains in passive obstacles and through microchannels, as a mimic for cellular motility. The project will provide you with in-depth training in cutting-edge synthesis and characterization techniques in soft matter and in micro/nanofluidic fabrication. You will also learn theoretical concepts underpinning the study of active matter, colloidal systems and polymers, besides gaining expertise in tools such as image-analysis. The Project can be the springboard for an exciting research career in microfluidics, soft condensed matter, nanosciences, or biophysics.

## Expected outcomes

This project is expected to develop a model system, to provide insights into cell motility in biology. These learnings will be published as impactful papers in leading journals. The likelihood of this work resulting in patentable inventions is low. The deliverables are primarily in terms of improved understanding of a biologically relevant phenomenon through the development of a model colloidal system.

## How will the project address the Goals of the above Themes?

This project will develop novel active nanomaterials – these represent interesting systems in their own right. Here, our interest is in using these as model systems for the study of cell motility. However, such systems might have implications for colloidal nanomachines that can, for example, provide targeted delivery of molecules loaded on the colloidal particles.

## Capabilities and Degrees Required

*List the ideal set of capabilities that a student should have for this project. Be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.*

Degree in Chemical/Mechanical Engineering, Chemistry (General or Physical Chemistry) or Physics. Exposure to polymers or colloids would be useful.

## Potential Collaborators

*Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.*

Monash - Prof. A. Neild (microfluidics), Prof. J. Soria (μPIV measurements), and Prof. M O'Bryan (sperm development and function).

Select up to **(4)** keywords from the Academy's approved keyword list **(available at http://www.iitbmonash.org/becoming-a-research-supervisor/)** relating to this project to make it easier for the students to apply.

**Nanotechnology, nanoscience, Bioscience, Biomedical Engineering**