<u>PhD project</u>

Kinetic theory applied to the study of the interaction between tumours and their micro-environment

INSTITUTION AND START DATE:
To start from October 2018, Faculty of Mathematics, University of Vienna.
PhD SUPERVISORS:
Dr Sara Merino-Aceituno (main) and Prof Christian Schmeiser (both based at the Faculty of Mathematics at the University of Vienna).
FUNDING AND DURATION: Fully funded position for 3 years.

GENERAL DESCRIPTION OF THE PROJECT:
Many key questions in science involve emergent properties, i.e., to understand how observable or large-scale phenomena arises from the underlying microscopic structure. While knowledge can be obtain on physical systems at the microscopic and macroscopic scales, it is not in general possible to establish the link between them experimentally. To set the missing link, we need to use mathematical tools, especially those coming from kinetic theory [1,2].

This project will apply tools from kinetic theory to understand how the micro-environment of a tumour affects its development. The mechanical interaction between a tumour and its surrounding tissue is a key determinant of cancer progression [3]. Effective new inhibitors have been discovered to disrupt this interaction, but the mechanisms by which this affects tumour development remain to be fully elucidated. The goal is to understand the impact of mechanical and topologic properties of the extracellular matrix (ECM) on tumour progression; the adaptive response of tumour to ECM perturbations; and to use this knowledge to develop a virtual treatment simulator predictive of an optimised treatment approach.

To achieve this goal, first, a mathematical model needs to be developed at the microscopic scale accounting for the mechanical interactions between the tumoral cells and the surrounding collagen fibers, inspired on [4]. This model will be developed jointly with a team of biologists (see 'Partners' below). Second, this model will be validated against experimental data. Thirdly, kinetic theory tools will be deployed to derive a macroscopic description from the microscopic model, extending the results in [5]. The macroscopic model will be analysed, simulated and compared with experimental data.

REFERENCES:
[1] Villani, C. (2002). A review of mathematical topics in collisional kinetic theory. *Handbook of mathematical fluid dynamics*, *1*(71-305), 3-8.
[2] Cercignani, C., Illner, R., & Pulvirenti, M. (2013). *The mathematical theory of dilute gases* (Vol. 106). Springer Science & Business Media.
[3] H. Tang et al, *Lysyl oxidase drives tumour progression by trapping EGF receptors at the cell surface*, Nature Communications, 8:14909 (2017).

[4] D. Peurichard et al, *Simple mechanical cues could explain adipose tissue morphology*, J. Theoret. Biol. 429:61 (2017).
[5] Degond et al, (2016). *Continuum model for linked fibers with alignment interactions*. Mathematical Models and Methods in Applied Sciences, *26*(02), 269-318.

PROJECT PARTNERS:
This project is in collaboration with the group of biologists:
- Caroline Springer, Dan Niculescu-Duvaz (Cancer Research UK Manchester)
and mathematicians:
- Pierre Degond (Imperial College London), Diane Peurichard (INRIA Paris).

REQUIREMENTS:
Normally, an undergraduate and MSc in Mathematics with an excellent command of mathematical analysis (specially desirable if knowledge on partial differential equations); good knowledge, experience and a taste for programming and numerical simulations; willingness to work in teams that include biologists.
Knowledge on kinetic theory is not required (it will be learned during the PhD).

CONTACT:
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