



Offre n°2024-07290

PhD Position F/M Mathematical and physical modeling of the DNA transfection by means of pulsed electric fields (IDP 2024)

Type de contrat : Fixed-term contract

Niveau de diplôme exigé : Graduate degree or equivalent

Fonction : PhD Position

A propos du centre ou de la direction fonctionnelle

The Inria center at the University of Bordeaux is one of the nine Inria centers in France and has about twenty research teams. The Inria centre is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative SMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute...

Contexte et atouts du poste

The team MONC has developed a deep expertise on the modeling of electroporation from the cell scale to the tissue scale, including clinical application. The thesis proposal aims to push forward this expertise by addressing the problem of modeling DNA transfection by means of electroporating fields, which is a booming subject in cancer immunotherapy. Roughly speaking, the goal is to develop a relevant and tractable model of DNA transfection by electroporation, to enable protocol optimization.

Mission confiée

The first goal of the thesis is to propose a new model of membrane based on local membrane composition – so called Landau Ginzburg models. A first work will consist in performing the mathematical analysis of the Cahn-Hilliard model to estimate the characteristic size of the defects, the characteristic time for the phase separation, and the duration and the amplitude of the electric fields to create defects. Alfaro et al. has studied the case of Allen-Cahn but the Cahn-Hilliard model with non local source term has not been investigated yet. In a second task, the goal is to derive rigorously a 2D model, thanks to an asymptotic analysis with respect to the thickness of the membrane. The goal is to obtain a 2D surface effective model of the membrane to reduce the cost of computation.

The asymptotic model should be similar to a model A (or Allen-Cahn) type model for the phase order as in the recent PhD thesis of P. Jaramillo (Univ. Bordeaux, Dec. 2023), with source terms derived from the asymptotic expansion. Once the model of membrane permeabilisation will be obtained, the challenge of the PhD will consist in describing the displacement of large charged molecules as DNA through the membrane. Interestingly, large molecules do not diffuse across the membrane but are internalized by electrophoretic forces. However due to their charge, DNA molecules behave like a dipole, that locally perturbs the electrostatic field. A moving source term has thus to be added in the above Poisson equation, and well-designed transmission conditions across the membrane are required for the DNA transport. From the numerical view point, specific well adapted numerical immersed boundary methods will be developed to tackle the numerical difficulties raised by the discontinuities across the membrane.

References (max 5):

- J.M. Escoffre, T. Portet, C. Favard, J. Teissié, D. S. Dean, M.-P. Rols, Electromediated formation of DNA complexes with cell membranes and its consequences for gene delivery, *Biochimica et Biophysica Acta (BBA) - Biomembranes*, Volume 1808, Issue 6, 2011
- P. Jaramillo Aguayo, A. Collin, C. Poignard, Phase-field model of bilipid membrane electroporation, *Journal of Mathematical Biology* (2023) 87:18.
- M. Leguebe, A. Silve, L. Mir, and C. Poignard. Conducting and permeable states of cell membrane submitted to high voltage pulses: Mathematical and numerical studies validated by the experiments. *Journal of Theoretical Biology*, 360:83–94, Nov. 2014
- R. Smeets, U. Keyser, D. Krapf, et al., Salt Dependence of Ion Transport and DNA Translocation through Solid- State Nanopores *Nano Letters*, 6(1): 89–95, 2006.

Compétences

Strong background in PDE and numerical analysis, with an appetite for biophysical problems.

Avantages

- Subsidized meals
- Partial reimbursement of public transport costs
- Possibility of teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Rémunération

- 2100€ / month (before taxes) during the first 2 years,
- 2190€ / month (before taxes) during the third year.

Informations générales

- **Thème/Domaine** : Modeling and Control for Life Sciences
- **Ville** : Talence
- **Centre Inria** : [Centre Inria de l'université de Bordeaux](#)
- **Date de prise de fonction souhaitée** : 2024-10-01
- **Durée de contrat** : 3 years
- **Date limite pour postuler** : 2024-05-03

Contacts

- **Équipe Inria** : [MONC](#)
- **Directeur de thèse** :
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A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

Attention: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

Consignes pour postuler

Thank you to send:

- CV
- Cover letter
- Master marks and ranking
- Support letter(s)

Sécurité défense :

Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

Politique de recrutement :

Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.