



Mathematical modeling of Cortical Spreading Depression (CSD)

SUMMARY OF THE PROJECT.

Cortical Spreading Depression (CSD) refers to a wave of depolarized electrical activity that is generated in specific brain regions and propagates through large parts of the cortex; see for instance [here](#). This is associated with pathological states of the brain that can correspond, depending on the case, to migraines or stroke. Our team for this project consists of three mathematician/modelers and one electrophysiologist. We have already derived a model accounting for the initiation of CSD, following a biological hypothesis for which the experimentalist of the team has preliminary data. This is a *micro-circuit* composed of two neural populations (each of which represented by one average neuron), one excitatory and one inhibitory. We also consider evolution equations for pump dynamics and slowly-varying ionic concentrations, which are known to play an important role in this ignition process. Our model is based on the conductance formalism [3] and it has been simulated using a dedicated software [2]. The main objectives of this internship are

1. to understand our model and reproduce our simulations (see [1]),
2. to port our code to an environment that supports larger simulations,
3. to simulate large networks extending our model and possibly including noise terms.

SUPERVISORY TEAM.

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PREREQUISITES TO APPLY.

- Basic notions of differential equations (see, e.g., [4])
- Basic notions of neuronal modeling (essentially conductance-based models as described in, e.g., [3])
- Notions of programming (e.g. in MATLAB, C++, PYTHON, JULIA, etc..)

SHORT BIBLIOGRAPHY.

- [1] M. Desroches, O. Faugeras, M. Krupa and M. Mantegazza, *Modeling cortical spreading depression induced by the hyperactivity of interneurons*, HAL e-print: [HAL-01520200](#).
- [2] G. B. Ermentrout, *Simulating, analysing and animating dynamical systems: a guide to XPPAUT for researchers and students*, SIAM, 2008. Code freely available [HERE](#).
- [3] G. B. Ermentrout and D. Terman, *Mathematical Foundations of Neuroscience*, Springer, 2010.
- [4] L. Perko, *Differential Equations and Dynamical Systems*, 3rd Edition, Springer-Verlag, 2000.