

M2 internship in Soft Matter and Statistical Physics 2027

Possibility of continuation into a funded PhD

Neural mechanisms for working memory

Arthur Leblois, Directeur de recherche (CNRS), arthur.leblois@u-bordeaux.fr

Keywords: Neuronal networks, non-linear systems dynamics, attractor dynamics, data analysis

Context: Understanding brain function requires bridging multiple analysis scales, from synaptic dynamics to large-scale neuronal population activity. Neuronal networks generate large-scale activity patterns that support cognitive function. However, understanding how the anatomical and physiological properties of the network shape network activity and function is still a major challenge. Working memory is a cognitive process well suited to study this link as it requires transient maintenance of information over short delays (seconds), bridging fast sensory processing (milliseconds) and long-term memory retention (days). It is defined as the ability to temporarily store and manipulate behaviourally relevant information. **The objective of our project is to elucidate how synaptic properties give rise to population activity patterns in working memory, which could reveal fundamental principles linking synaptic physiology and network computation.** The project relies on a hybrid approach combining neuronal recordings and theoretical modelling.

M2 project: The intern will work on the construction of predictive neuronal network models constrained by available experimental evidence both from the existing scientific literature and from the dataset collected by the project experimental partner. He/she will work exclusively at the interface between models and large-scale data analysis, without participating in animal handling. Depending on the student's interests, the project can emphasize modelling or data analysis.

Key tasks may include:

- o Development of models: Implementation and analysis of attractor models (rate-based and spiking neurons networks) incorporating realistic physiological parameters (short-term plasticity, excitation/inhibition balance) to test hypotheses regarding memory state stability.
- o Electrophysiological data analysis: Processing and spike-sorting of Neuropixels 2.0 recording data acquired in the mediodorsal prefrontal cortex and the posterior parietal cortex.
- o Application of decoding methods (Machine Learning, SVM, Principal Component Analysis) to identify neuronal activity patterns associated with information maintenance.

Candidate Profile

- Education: Master's student (1st/2nd year) in Physics, Applied Maths, Computer Sci, or Engineering.
- Technical Skills: Proficiency in Python or MATLAB programming for data analysis and simulation; Prior experience in non-linear systems dynamics is a plus.
- Personal Qualities: Analytical mindset, mathematical rigor, autonomy.

Internship Details

- Duration: up to 6 months, ideally starting early 2027.
- Location : Institut des Maladies Neurodégénératives (IMN), Neurocampus, Univ Bordeaux.
- Supervision: Primary supervision by Arthur Leblois, with collaboration involving Alexis Dubreuil (modeling) and Frédéric Lanore (experimental data).

- The internship is funded according to the standard French M2 internship allowance.
- Prospects: This internship offers exceptional training in computational neuroscience. Funding is also available for a three-year PhD that will extend this research. This opportunity allows you to work on fundamental questions of cognition using state-of-the-art tools in artificial intelligence and systems dynamics, within a leading research team.
- Application: Interested candidates should send their CV and detail their end-of-studies projects and their skills in modeling and data analysis to: arthur.leblois@u-bordeaux.fr.