**Master 2:** ***International Centre for Fundamental Physics***

## ***INTERNSHIP PROPOSAL***

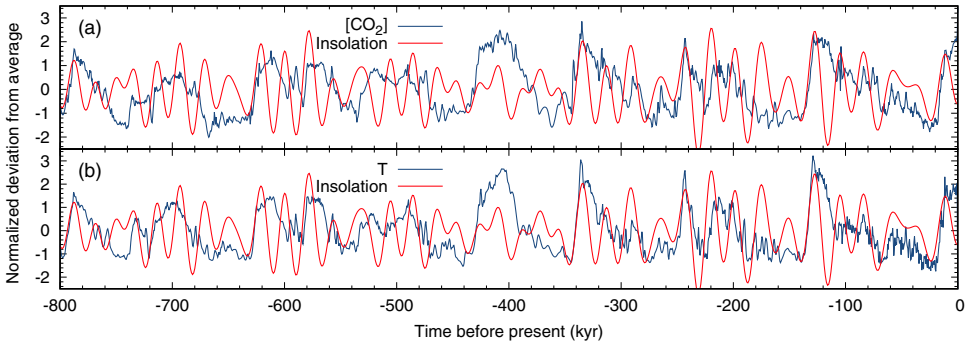
*(One page maximum)*

Laboratory name: LISN, Université Paris-Saclay
CNRS identification code: UMR 9015
Internship director'surname: S Chibbaro, C Furtlehner, L Mathelin
e-mail: sergio.chibbaro@upsaclay.fr Phone number: 01 69 15 58 40
Web page: Scholar profiles
Internship location: LISN, Saclay

Thesis possibility after internship: YES
Funding: NO (maybe) If YES, which type of funding:

### Deep Learning of causality

This project aims at developing new Machine Learning techniques tailored to the modelling and inference of physical complex systems.
A recurrent problem in Physics and Engineering Sciences is to try to predict the future evolution of a physical system according to the partial information known at the current time, and possibly during a recent past. In the absence of a model, this evolution must be learned from the available data and usually takes the form of an optimization problem, possibly under constraints, informed by the potentially large number of observables. This optimization problem can then be of large size and thus present all the associated problems (many local minima of the cost function, need for a lot of data, etc.). To improve the quality (e.g., generalizability) and the efficiency of the learning process (e.g., amount of data needed, dimension of the optimization space, computational load, etc.), it is often essential to identify only those observations that have a causal link with the quantity to be predicted. In order to avoid conservative choices that have a strong impact on quality and efficiency, it is essential to determine this cone and to restrict the learning problem to it.




More generally, to understand the causality relation between different phenomena is one of the most important, and difficult, issue in physics as well as in philosophy.
An example is given in figure concerning climate time-series (Baldovin et al. Sci. Rep 2022). Recent results in statistical physics suggest that in some cases the causality link could be understood. It would be very interesting to develop learning strategy capable to recognise this link, and this is the ultimate goal of the project.

Condensed Matter Physics: YES Soft Matter and Biological Physics: YES
Quantum Physics: NO Theoretical Physics: YES