ÉCOLE DOCTORALE
SCIENCES DE LA TERRE ET DE L'ENVIRONNEMENT
ET PHYSIQUE DE L'UNIVERS, PARIS

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Subject title: Mechanical modelling of tidal modulation during seismic cycle using the hierarchical asperity model under various conditions of stress perturbations.

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Presentation of the subject: (Maximum 2 pages)

Small transient stress perturbations are prone to trigger earthquakes and a better understanding of the dynamic of earthquake triggering by transient stress perturbations is essential in order to improve our understanding of earthquake physics and our consideration of seismic hazard. In the Earth's crust, these transient stress changes can be caused by various sources (passing of seismic waves, forcing by tides, hydrological load, and other seasonal climatic loads). In the framework of the three-year collaborative project SESAME (SEismicity: Statistical Analysis, Modeling and Experiments; 2023-2026) between Laboratoire de Géologie de l'Ecole Normale Supérieure (LG-ENS, Paris, France) and University of Tokyo (Japan), a PhD student is expected to develop numerical models, ranging from statistical physics to advanced solid/fault mechanics towards to our better understanding on the mechanical conditions favorable to a small stress perturbation such as tidal and seasonal triggering, at both the natural and laboratory scales.

The principal scientific question is the following: ***How does the modulation (susceptibility) of seismicity changes with the rate of tectonic loading, the amplitude and frequency of stress perturbations, the timing within the earthquake cycle and finally, the magnitude of the earthquakes considered?***

The following three ingredients from previous works are to be considered :

i) We have developed the multi-scale multi-asperity model (Ide & Aochi, 2005), to the case of periodic loading, or impulsive, to look into the specific case of seismicity modulation during the nucleation phase of large earthquakes, in order to test the natural and experimental observations of increased susceptibility as time to failure decreases.

ii) We have developed the Rate & State friction fault network model (Romanet et al., 2018), to the case of periodic loading, in order to carry out a spatial mapping of the parameters of the susceptibility to perturbations as a function of their amplitude and frequency, as well as tectonic loading, in order to compare experimental and natural observations to the model. Particular attention will be given to *b*-value modulation in these models. The numerical framework is already well developed and tested for this aspect of the problem.

iii) Finally, we have also developed statistical physics models (Pétrélis et al., 2021) to the case of multiple overlapping periods and amplitudes of stress perturbations, such as that of daily and fortnightly tides for instance, in order to analyse jointly the experimental, numerical and natural catalogues using the tools of statistical Physics.

The primary target is the Japanese subduction where various phenomena are coupled: tremors, low-frequency earthquake, slow earthquakes, static nucleation, dynamic nucleation, foreshocks, aftershocks, afterslip. Furthermore, another type of the plate boundary is also to discuss such as the East Anatolian fault such as the 2023 earthquakes.

The PhD student, based on LG-ENS and fully funded by the program, is expected to work collaboratively with different researchers and students within ENS and also with the University of Tokyo. A stay of a few months at the University of Tokyo is planned to refine the numerical models as well as to analyze the seismic data. We seek a highly motivated student, having a strong interest in earthquake mechanics. Background acquired on earthquake seismology, rock mechanics and geophysics, scientific computing will be appreciated. The applicant should hold a master degree in Earth Science or related field. Enquiries regarding this PhD project might be addressed to either of the three laboratory members mentioned on the top.

The application should contain (1) a full CV, (2) a cover letter including research interests and motivation, (3) the contact information of at least two potential referees, (4) A scanned copy of diploma, and (5) transcripts of records. The application should be submitted to aochi@geologie.ens.fr preferably before **30th April 2023**, when we start the selection process. We continue recruiting until the position is filled (**final deadline - the end of May 2023**). The identified candidate will need to pass the approbation process (in June 2023) at the Ecole Doctorale STEP'UP.

Ide, S., & Aochi, H. (2005). *Journal of Geophysical Research: Solid Earth*, *110*(B11). Romanet, P., Bhat, H. S., Jolivet, R., & Madariaga, R. (2018). *Geophysical Research Letters*, *45*(10), 4809-4819. Pétrélis, F., Chanard, K., Schubnel, A., & Hatano, T. (2021). *Journal of Statistical Mechanics: Theory and Experiment*, *2021*(2), 023404.