One year Post-Doc position in Rennes, France

Starting **Autumn 2019**.

- **Subject**: Rare event simulation algorithms with importance splitting. Theoretical and practical issues.
- **Location:** Rennes 1 University, France. IRMAR (maths department, https://irmar.univ-rennes1.fr/en) & Inria (team SIMSMART https://team.inria.fr/simsmart/).
- **Field:** Computational probability and statistics, large deviation analysis.
- **Key Words**: Rare Events, Large Deviations, Sequential Monte Carlo, Particle Methods.
- **Supervisor:** Mathias Rousset (mathias.rousset@inria.fr).

Post-Doc objectives

The estimation of the probability of a rare event is a crucial problem in areas such as reliability (telecommunications, air traffic control, nuclear security), molecular simulation (change of "metastable condition"), or meteorology / climatology (simulation of extreme episodes). In complex systems, the analytic study is out of reach, and a Monte Carlo method must be used. When the event is really rare (say 10^{-10}), a naïve Monte Carlo approach does not work. We are interested in the so-called static case, where we want to estimate $\mathbb{P}(s(X) > s_0)$, with X a random variable, s a score function. We suppose that we know how to simulate: (i) the law π of X; (ii) a reversible P kernel Markov chain for this law π.

A now-common technique is to write the rare event by nesting increasingly rare events $A_k = \{s(X) > l_k\}$ for $l_1 < \cdots < l_n = l$, and to estimate the probabilities $\mathbb{P}(A_k|A_{k-1})$. The most standard version of the algorithm falls within the framework of sequential Monte-Carlo type particle methods developed, among others, by P. Del Moral and A. Doucet. However, there are many optimized variants that do not fit into this framework and whose analysis is either incomplete or non-existent.

The purpose will be to set up the mathematical and methodological analysis of such algorithms, and to propose numerical simulations illustrating the methodological issues. Depending on the candidate's profile, the post-doc can focus on one of the following two open problems.

- Assuming that the underlying model (*i.e.* P_ϵ and its invariant distribution π_ϵ) satisfies a large deviation principle when $\epsilon \to 0$, the large deviation analysis of such particle models is an open problem. A specific variant reduces to a rather simple Markov chain, whose analysis seems to be amenable in the limit $\epsilon \to 0$.
- An idea to be explored is to resort to an underlying hierarchy of models with increasing computational complexity, which happens for instance in a 'big data' context. The associated methodological questions are largely open, in particular the implementation of a strategy that optimize the variance $\times$ computational cost product.