Adaptive tensor approximation and model reduction for high-dimensional quantum systems | 11GS	**Start Date:** January 1st 2017
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Abstract: Our description of nature in general, and in particular of the quantum world that provides the physical support to quantum technologies, is mostly based on models formulated in terms of (partial) differential equations (PDEs). The analysis and (approximate) solution enable our understanding, predicting power and engineering capabilities of such complex processes. Despite the tremendous successes the scientific community has obtained following this path, there are still strong limitations that hinder our ability of describing, understanding and controlling such systems and their time evolution. The reason is that the complexity and the dimensionality of such systems has been growing by far faster than the availability of current computer resources. Indeed, high dimensional systems arising from quantum physics and many-body quantum systems very quickly saturate the computational power even of the most powerful supercomputers.

A possible way-out of this challenging scenario is to introduce approximations to reduce the number of relevant variables, which allows for a description of the process of interest (even though sometimes under quite strong assumptions). Such approaches have been introduced (more or less independent from each other) both in Physics and in Mathematics. Successful approaches of this kind in Physics are Hartree-Fock approaches, density functional theory, cumulant expansions, tensor network methods, and stochastic approaches for properly reduced systems such as Monte Carlo and stochastic Liouville-von Neumann equations.

In this project, we aim to (1) explore the synergies and the possible applications of the knowledge developed in the last decades in Numerical Mathematics and Quantum Technologies; (2) develop, analyse and realize new numerical approximation methods for instationary parameterized high-dimensional PDEs with specific focus to quantum processes.