The DAEMoN theory project aims to exploit photonic nanostructures for novel ways of controlling dynamics of asymmetric quantum emitters, such as selected molecules or quantum dots.

Photonic nanostructures are metallic or dielectric particles of sizes a thousand times smaller than the diameter of a human hair. The project is focused on their remarkable ability to concentrate light into nanoscopic regions of space, accompanied by enhancement of light energy density in these regions, called hot spots. If a molecule is positioned in a hot spot created by a nanostructure, its interaction strength to light is radically enhanced. In the current era of quantum technologies, a direct application is found: molecules can be used as miniaturized memories, i.e. storage units for quantum information carried by photons. At vicinity of nanostructures, due to the increased interaction strength, information can be rewritten between a carrier and a memory in a faster way. Suitably designed nanostructures can be used to determine emission properties of molecules, e.g. increase a thousandfold the rate at which they are able to emit light, to influence coupling strength between remote molecules, in general: to boost in magnitude different processes which otherwise might even be too weak to be observed.

The DAEMoN project was born from an observation that there might exist an additional interaction channel between quantum emitters and light, which has hardly been studied or exploited before. This interaction channel is related to the emitters' spatial asymmetry, and in typical conditions is rather weak. In DAEMoN, we propose to use photonic nanostructures for a substantial enhancement of this channel to a regime where related effects could be detected and become practical. We will comprehensively study the potential of nanostructures in this respect, and engineer nanostructured geometries for specific purposes, e.g. for improvement of quantum memory by quenching information loss rate.

Results of DAEMoN may have both fundamental character and relevance for future applications. The fundamental character is due to the fact that the effect of asymmetry on free and controlled dynamics will, to the best of our knowledge, be analyzed for the first time in such a comprehensive manner, including effects hardly ever before studied previously. Thus, if our results are promising, DAEMoN might be a starting point for a whole new research line. Relevance for future applications is related to the expectation that our results will provide new indications on the possibility to control, by properly engineering the geometrical and dispersive properties of nanostructures, the dynamics of systems that are interesting for quantum information and computation. In particular, we hope that our output might be exploited for the new generation of quantum technologies, including optically tunable sources of radiation, but also as novel means of controlling quantum dynamics and interactions for computing devices, memories, or for metrology.