Light-matter interactions in space-time metamaterials

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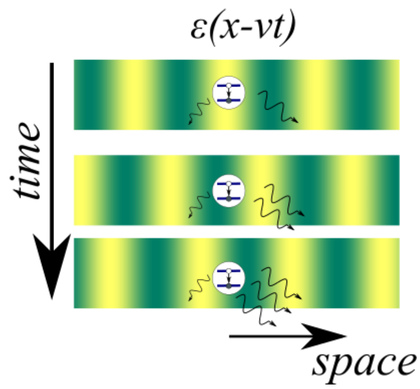
Metamaterials are one of the most striking advances in science and technology of recent years. In the last two decades, these artificial media with subwavelength spatial structuring have enabled a plethora of ways of wave control such as negative refraction, fast and slow light propagation, or ultra-flat and even perfect lenses [1,2].

Recently, time has emerged as a new degree of freedom for metamaterials. In temporal metamaterials, the electromagnetic parameters are designed to vary not only in space but also in time. These temporal variations allow for new pathways in wave control [3]. In particular, in these time-dependent systems, energy is not necessarily conserved, and a linear bias can be imposed through travelling wave modulations, permitting to break the fundamental principle of reciprocity (symmetry of propagation in opposite directions) [4]. Travelling wave modulations thus realise “spatio-temporal metamaterials”, a medium whose electromagnetic parameters (permittivity and/or permeability) are modulated in space and time such that they appear to move along one direction.

This project goes beyond the study of classical wave physics in temporal metamaterials by studying light-matter interactions in these new media. Recent research in this topic has already shown that exotic QED processes can take place owing to the temporal modulation [5]. The objective of this project is thus to consider quantum emitters placed in a spatio-temporal metamaterial, and study QED effects including the spontaneous emission of one emitter and the interaction between two emitters. Methods to be employed include the light-matter interaction Hamiltonian, Fermi Golden’s rule and the master equation formalism.



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