INSTITUT DE PHYSIQUE ET CHIMIE DES MATERIAUX DE STRASBOURG
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Séminaire AXE 1 - Sciences et Matériaux Quantiques

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Manipulating light with time-varying media

A sudden change in a material refractive index – a time interface – induces frequency conversion accompanied by both forward and backward propagating waves, a phenomenon termed time refraction and reflection. Building on this temporal effect, a myriad of new physical phenomena with no counterpart in static systems has been unraveled, leading to the field of time-varying media [1]. Within this field, materials whose electric permittivity is modulated periodically in time, termed photonic time crystals, have attracted considerable attention for their ability to open momentum bandgaps hosting amplifying modes. Moreover, a simultaneous structuring of permittivity in space and time, creating so-called space-time photonic crystals, has sparked interest for its breaking of reciprocity.

In this talk, I will present some recent advances we made in this field. We will investigate the interaction between a dipolar emitter and a dispersive photonic time crystal, and unveil that temporal modulation enables gain without relying on momentum gaps, exceptional points, or any instability [2]. This gain manifests as a negative power dissipated by the dipole, effectively converting dipole emission into dipole absorption. Using a scattering matrix approach, we demonstrate that the same mechanism may arise in a slab of indium tin oxide whose plasma frequency is modulated periodically [3]. In this scenario, the modulation allows surface plasmons to transfer near-field nonradiative gain to a dipolar emitter. Finally, I will present the unique properties of interface states that appear in systems made of space-time crystals with travelling-wave modulations, and discuss their topological origin [4].

[1] E. Galiffi et al., Adv. Photonics 4, 1, 014002 (2022)
[2] T. F. Allard, J. E. Sustaeta-Osuna, F. J. Garcia-Vidal and P. A. Huidobro, Phys. Rev. Lett. 136, 106903 (2026)
[3] J. E. Sustaeta-Osuna, T. F. Allard, F. J. Garcia-Vidal and P. A. Huidobro, Phys. Rev. Lett., Accepted (2026) ; arXiv:2509.16153
[4] A. Caballero, T. F. Allard and P. A. Huidobro, ACS Photonics, Accepted (2026) ; arXiv:2510.18523

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