

Space-time wave packet revivals

The celebrated Talbot effect refers to periodic emergence of exact replicas of a diffracting paraxial quasi-monochromatic optical field with a periodic transverse spatial profile in free space. The effect is but a particular manifestation of a generic phenomenon of periodic revivals of wave packets with discrete spatial or temporal spectra in conservative wave systems which are ubiquitous in physics, from optics and acoustics to condensed matter physics. The Talbot effect has found numerous applications to metrology, interferometry, microscopy, temporal cloaking and even number factorization.

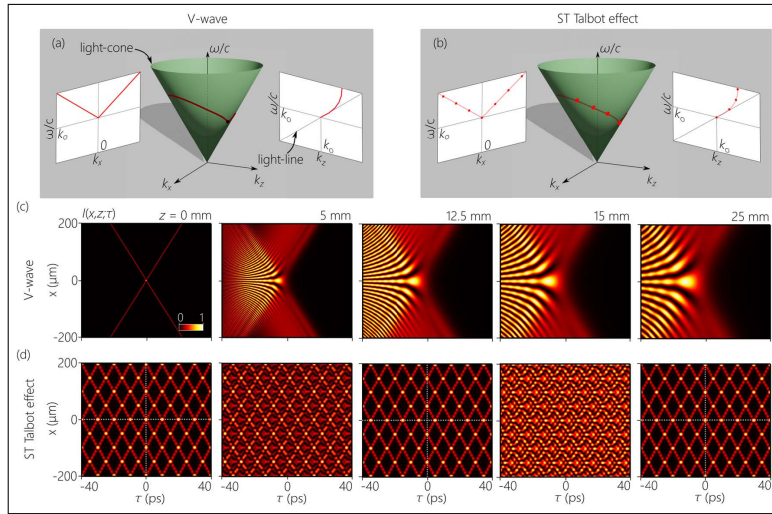


FIG. 1. Illustrating the space-time Talbot effect. (a) Representation of the spectral support domain of a V-wave on the surface of the light-cone and its spectral projections onto the $(k_x, \omega/c)$ and $(k_z, \omega/c)$ planes. (b) The ST Talbot effect is realized by discretizing the spatiotemporal spectrum of the V-wave in (a). (c) Spatiotemporal profiles $I(x, z; \tau)$ of a V-wave propagating in free space in a reference frame moving at the speed of light and experiencing diffraction-induced GVD.

We have recently demonstrated that space-time wave packets (STWP), whose spatial and temporal degrees of freedom are classically entangled, can shed new light on the Talbot effect. Specifically STWPs with periodic spatial profiles give rise to a veiled Talbot effect that can only be observed in time-resolved experiments [1]. Further, carefully prepared STWPs, the so-called V-waves manifest a space-time Talbot effect whereby spatially or time periodic optical V-waves feature recurring revivals in both space and time over the same characteristic Talbot distance in free space as is visualized in Fig. 1. This work is featured on cover of

the APL Photonics issue it is published in as well as in popular press [3]. Moreover, free-space diffraction of STWPs can induce temporal dispersion such that STWPs can exhibit a temporal Talbot effect even in free space in absence of any medium dispersion [4]. We have closely collaborated with the group of Prof. Ayman Abouraddy from CREOL, University of Central Florida, USA where all experiments were carried out.

- [1] M. Yessenov, L. A. Hall, S. A. Ponomarenko, and A. F. Abouraddy, “Veiled Talbot Effect,” *Phys. Rev. Lett.*, **125**, 243901 (2020).
- [2] L. A. Hall, M. Yessenov, S. A. Ponomarenko, and A. F. Abouraddy, “The space-time Talbot effect [**On Cover**],” *APL Photonics* **6**, 056105 (2021).
- [3] Y. Yiu, “Talbot effect observed over space-time for the first time,” *Scilight*, May 2021, <https://doi.org/10.1063/10.0005054>.
- [4] L. Hall, S. A. Ponomarenko, and A. Abouraddy, “Temporal Talbot effect in free space,” *Opt. Lett.*, **46**, 3107 (2021).