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Trajectory management of self-accelerating beams through Fourier-space phase engineering

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Borrowing the concept from time domain, non-stationary beams can be defined as a monochromatic coherent light whose intensity shapes vary during propagation. Therefore, the concept for non-stationary signal processing can be employed in analogy to study the linear dynamics of these beams. Typical examples of non-stationary beams

are the self-accelerating beams featured by a transversely moving main hump. To date, such beam trajectories are either engineered by solving wave equations in separable coordinate systems or synthesized in real space by employing the stationary phase or catastrophe theory. In this paper, we

study non-stationary beams in a frequency-like manner and demonstrate the prediction/engineering of their trajectories. While in time domain the spectral phase gradient is related to the group delay, in the spatial domain the same quantity is associated with the local position of a light beam. In this framework, we found that the single beam trajectory of self-accelerating light at different propagation distances is managed by different key spatial frequencies. The properties of self-accelerating beams, including self-bending and self-healing are re-examined in the language of frequency. In addition, multiple trajectories of non-stationary beams are managed by different parts of the spectrum and each one of them is a convex curve. Through this new scheme, we can not only trace the beam path of the maximum intensity for a known spectral phase, but also construct a phase structure in the Fourier space for desired beam trajectories. This method can also be readily used for studying vector non-stationary beams. Furthermore, our analysis can be straightforward applied to non-stationary waves/fields in other systems.

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