Temporal cavities as temporal mode filters for frequency combs

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Quantum information science provides new ways to encode, transmit, and manipulate information in ways not possible with classical technologies. In particular, quantum communication and the distribution of information in a quantum network can be implemented efficiently using an orthogonal set of broadband optical pulses: Photonic Temporal Modes(PTM). PTMs offer a promising approach to quantum information processing and quantum metrology due to their flexibility, quality, and reliability.

However, manipulating PTM without destroying the encoded quantum information is challenging. Although techniques such as the quantum pulse gate (QPG) have been developed to address this challenge, **a genuine temporal mode filter** is currently missing.

To address this, we introduce in this work the original concept of **"temporal cavity"** [1] - a time-domain equivalent of spatial mode-cleaning cavities. We illustrate its working principle and we study its application as a genuine mode filter that does not change the carrier frequency, nor the shape of the filtered mode, therefore preserving the orthogonality. This fundamental functionality has not been demonstrated to date and could be useful for multidimensional quantum information processing and classical and quantum metrology by enabling multiplexing and demultiplexing of temporal modes, including temporal mode-dependent detection, as well as the synthesis of multi-mode **quantum frequency combs**.

References

[1] B. Dioum, S. Srivastava, M. Karpiński, and G. Patera. Temporal cavities as temporal mode filters for frequency combs, 2023.