

# Towards on-chip atomic frequency references via two-photon absorption in laser-written vapor cells

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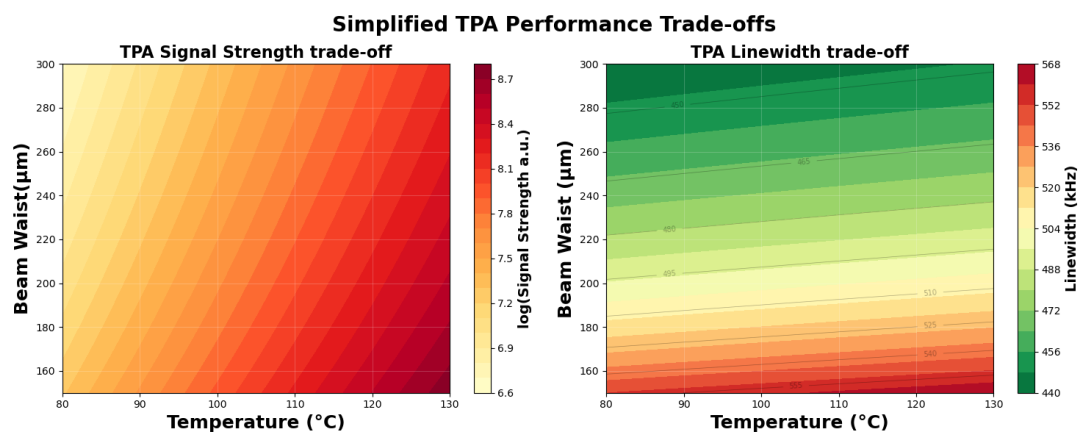
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**Abstract:** We discuss the miniaturisation of optical atomic clocks, with a particular focus on the pathway towards an on-chip frequency reference based on two-photon absorption in an alkali metal atomic vapor cell.

Portable atomic clocks that aim to improve on the stability of the Chip Scale Atomic Clock (CSAC), are becoming increasingly of interest for general Positioning, Navigation, and Timing (PNTs) applications. Atomic vapor cells offer a feasible platform for miniaturisation of optical clocks, with access to optical transitions with suitable linewidths and improved stabilities over their CSAC counterparts. Frequency stability can be provided by locking a 'clock' laser to a two-photon absorption transition generated in an atomic vapor cell [1].

While miniaturised configurations of these frequency references have been successfully reported on [2], they are limited by free space laser transmission and active alignment of optical components. This limits robustness as well as further miniaturisation and production scaling. Laser-written vapor cell (LWVC) technology [3,4] enables the construction of all-glass integrated atomic-photonics chips, that can surpass the free space limitations of current approaches and provide for wafer scale manufacturing.



**Fig. 1** Trade-off between two-photon absorption (TPA) signal strength and linewidth, calculated as functions of vapor cell temperature and laser beam waist. The left panel shows the signal strength, and the right panel the corresponding linewidth.

The frequency reference stability depends on how well different noise contributions are addressed. With our LWVC design we address some typical noise contributions such as light shifts, interatomic collisions, and background gas collisions. We discuss design and operational considerations for the LWVC frequency reference, including the signal strength–linewidth trade-off (Fig. 1), and their impact on the noise budget. Finally, we briefly discuss a roadmap towards a fully integrated atomic-photonics clock [5].

## References

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