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Fast and low-loss, all-optical phase modulation in warm rubidium vapour

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Low-loss high-speed switches are an integral component of future photonic quantum technologies, with applications in state generation, multiplexing, and the implementation of quantum gates. Phase modulation is one method of achieving this switching; however, existing optical phase modulators, such as Pockels cells and waveguided lithium niobate, offer either high bandwidth or low loss—not both. We demonstrate fast (100 MHz bandwidth), low-loss (83(2)%) phase shifting ($\Delta\phi = 0.90(0.05)\pi$) in a signal field, induced by a control field, and mediated by the two-photon $\{5S_{1/2} \rightarrow 5P_{3/2} \rightarrow 5D_{5/2}\}$ transition in ^{87}Rb vapour. The all-optical nature of the scheme circumvents restrictions of electronic phase modulators, where bandwidth and repetition rate can be limited by the requirement to rapidly modulate high voltages. We discuss routes to enhance both performance and scalability for application to a range of quantum and classical technologies.

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