ENGINEERING FASTER AND WARMER QUANTUM PHOTONIC SYSTEMS

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The transformative potential of quantum information technologies from quantum computers and secure networks to quantum-limited sensors is held back by a fundamental challenge: decoherence. Quantum states are fragile and easily disrupted by their environment, making them difficult to maintain and use in practical settings. While protecting systems from decoherence is paramount, a complementary and powerful strategy is to selectively enhance the very quantum interactions on which their functionality depends. By speeding up these key quantum processes, we can effectively outpace decoherence. This pathway also enables operation at higher temperatures and bandwidths. In this talk, we will present two advances that follow this principle. First, we introduce a new quantum emitter in diamond: the IL1 color center, which exhibits surprising natural decoupling from bulk phonons — a major source of decoherence — while simultaneously maintaining bright, fast optical emission. This unique combination of properties is promising to realize cryogen-free quantum network nodes and high-precision nanoscale sensors. Second, we present a blueprint for a high-efficiency microwave-to-optical transducer. To overcome the critical bottleneck of converting quantum information between these domains, our design employs a two-stage process via an intermediate-frequency state in the sub-THz range. This approach promises near-unity external conversion efficiency, dramatic thermal noise suppression, and removes the optical components from the dilution refrigerator, crucial advantages for connecting quantum processors over optical links. Together, these examples demonstrate how exploiting specific physical degrees of freedom that enhance the desired quantum interactions without compromising coherence can open the way to warmer, faster, and more practical quantum systems.