# A Slow-Light Laser Radar (**SLIDAR**)

Light detection and ranging (LIDAR) is used in a variety of remote sensing applications, such as measuring atmospheric properties, detecting chemical and biological agents and surveilling vehicles.[1] The key performance parameters of a LIDAR system include its transverse and longitudinal resolutions.

Similar to imaging systems, the far-field transverse resolution of LIDAR depends on the aperture size of its emitter. Recently, multi-aperture systems have been studied for various applications, such as high-performance telescopes and high-power lasers. Compared to a single large aperture, multi-aperture systems can achieve a larger effective aperture size—in other words, fine far-field transverse resolution, without the need for heavy and slow optomechanical components.

Since the signals from different emitters need to be coherently combined in the far-field, a multi-aperture LIDAR requires precise optical phase control of every emitter's output. Furthermore, a LIDAR working in a pulsed mode faces an additional challenge. When the beam is steered far off from the direction normal to the emitter array plane, the emitters at one side of the system become closer to the far-field target than those on the other. Thus, the signal pulses sent from different emitters may no longer overlap in time when they reach the far field. Such a group delay mismatch will degrade both the longitudinal and transverse resolutions. Thus, it is crucial to dynamically correct the group delay mismatch such that the pulsed signals emitted from different channels are always aligned properly in time when they reach the far field.

Earlier this year, we proposed and demonstrated a multi-aperture slow-light laser radar (SLIDAR) system.[2] We incorporate two independent fiber-based tunable slow light mechanisms, namely dispersive delay and stimulated Brillouin scattering (SBS) slow light, to realize dynamic group delay compensation while the
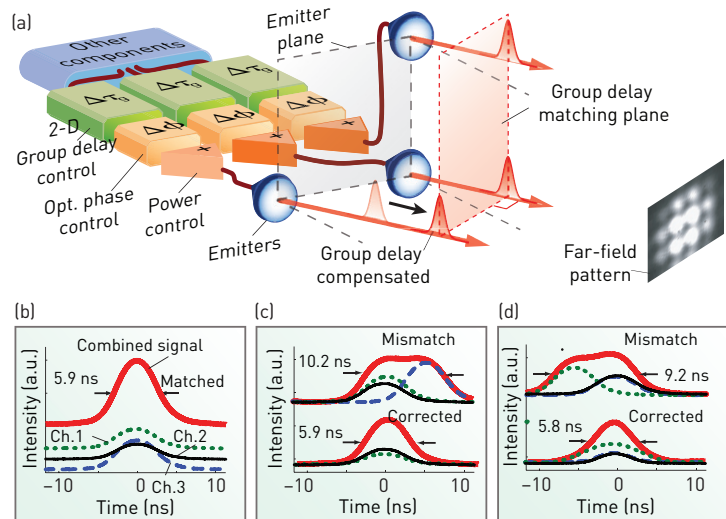
(a) A SLIDAR system capable of 2-D beam steering; normalized time traces of the returned signal when the system is (b) pointing on-axis, (c) tilted in the x direction, and (d) tilted in both the x and y directions. The thick red line is the combined signal, while the thin lines are the signal from three individual channels.

system scans in two orthogonal directions.[3,4] We also use a heterodyne locking scheme to control the optical phase of the output of each emitter.

We use three emitters arranged in a right-angle 2-D pattern. Such an arrangement contains all of the conceptual difficulties of a multi-channel system. Specifically, it requires simultaneous implementation of two types of slow light mechanisms as well as optical phase locking.

When the system is pointing at off-axis directions, the group delay mismatch will result in significant signal broadening, indicating serious degradation in longitudinal and transverse resolutions. When the 2-D group delay control units are turned on, the mismatch is compensated well and there is no pulse broadening in the returned signal. With our demonstration of all the key techniques, the implementation of a full-fledged SLIDAR system becomes straightforward. OPN

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