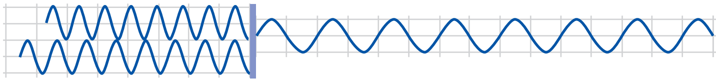
Errata to *Field Guide to Lidar*, First Printing

Lidar Detection Modes

corrected text:

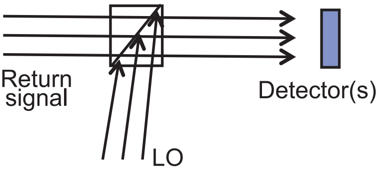
An optical detector only responds to the intensity of light. It cannot follow the rapid fluctuations of the 200- to 600-THz carrier frequencies of 0.5- to 1.5-μm light. When light hits a detector, it generates a voltage proportional to the square of the electric field of the impinging light. In **direct detection**, the lidar return hits the detector, causing a voltage proportional to both the light intensity and the square of the electric field. In **coherent lidar**, the return signal beats against a sample of the emitted signal, called the **local oscillator** (LO). In this case, the detector can respond to the beat (or difference) frequency between the return signal and the LO field:

$$I = 2E_{\text{sig}} \cdot E_{\text{LO}} \cdot \exp\left[-jt(\omega_{\text{sig}} - \omega_{\text{LO}})\right]$$



In **temporal heterodyne detection**, the LO and return signals are spatially aligned to interfere on the detector:

If they are not aligned, high-spatial-frequency fringes will lower heterodyne mixing efficiency. The frequency of the LO is offset so that the direction of target velocity can be determined, and to reduce **1/*f* noise**. If there is no frequency offset, temporal heterodyne detection is called **homodyne detection**.



In **spatial heterodyne detection**, also called **digital holography**, the LO and the return signal are slightly misaligned, as shown in the figure. The tilt between the LO and the return signal creates fringes that can be sampled by a detector array. If the angular tilt is too large, the fringes will be too rapid and will average out across a detector. In **phase shift interferometry**, the reflected wave is mixed with a like-frequency LO. The interferogram is measured on a 2D detector array. Multiple interferograms are recorded in which a known piston phase has been applied to the LO. Three or more interferograms are processed to extract the field amplitude and phase.

Avalanche Photodiodes and Direct Detection

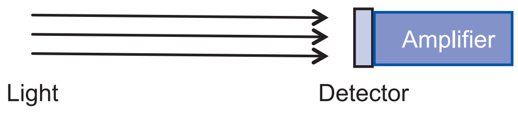
One way to reduce the effect of noise in **direct detection** is to use gain. This gain can be from a fiber amplifier before detection, but the most common type of gain is **avalanche gain** after detection. Expanding the noise terms results in

$$SNR = \frac{\langle i_s^2 \rangle}{\langle i_n^2 \rangle}$$

$$= \frac{G^2 \Re^2 P_s^2}{2eBG^2F[\Re(P_s + P_{LO} + P_{bk}) + P_{dks}] + 2eBi_{dks} + 4(kTB/R_L)}$$

First printing reads "Surface" instead of "Bulk."

Gain after detection reduces the influence of surface dark current and thermal noise. Background radiation is amplified in the same way that the signal is amplified. Bulk dark current can also be amplified in an **APD**.



Amplification adds noise. For a background-limited direct detection receiver,

$$SNR = \frac{\eta_D P_s^2}{2h\nu B P_{bk}}$$

Within the limit in which the signal shot noise dominates the other noise terms, the SNR is given by

$$SNR_{shot,lim} = \frac{\eta_D P_R}{2h\nu B}$$

Within this limit, the SNR is directly proportional to the number of photons received. This is the best that can be achieved and is the goal of using gain.