Noise in optical measurement This chapter introduces various detection methods of light and explains noise appearing in each method. Some explanations are phenomenological but they will be explained by quantum optics in later chapters.

Optical measurement Figure fig:photodetection(a) shows the direct detection. Photodetectors can convert photons to electrons to measure optical power, which is proportional to the number of photons per unit time.

Fig. fig:photodetection(b) shows the interferometric detection, where a beamsplitter (BS) is used to mix the signal light wave to be measured and another light wave called local oscillator (LO) light, and the output light waves of the BS are detected with photodetectors to measure the amplitude of light. When the optical frequencies of signal and LO are the same, the method is called homodyne. When they are different, the method is called heterodyne.

Furthermore, an optical amplifier is often used before photodetection as shown in Fig. fig:photodetection(c). This is called preamplification. Although not shown in the figure, it is also possible to conduct interferometric detection after preamplification.

In any case, the output signal of the photodetector contains noise due to various origins such as instability of light sources or optical systems, circuit noise of photodetector(s), and so on. We can somehow reduce these noises, but at last we will see 'quantum noise' that cannot be reduced by classical manner. Only quantum optics can control the quantum noise.

Here, before introducing various noise sources, we introduce direct detection, interferometric detection, and preamplification.

figure [width=9cm]fig/2-1$_photodetection.epsVariousphotodetectionmethods.(a)Directdetection.(b)Interferometric$