**Photon Transfer Curve**

1. **Photon Transfer**

The camera can be described with five transfer function, three related to the CCD and two associated with the off-chip signal processing circuitry. The input is given in units of incident photons and the output is achieved by encoding each pixel’s signal into a digital number . In order to convert the output signal DN into fundamental physical units, it is necessary to find the appropriate factors in converting DN units to photons or signal electrons.

is the camera gain constant given in units of and interacting . The two quantities are related through the quantum yield by . In order to calculate the two values, the number of incident photons or excited electrons doesn’t need to me measured.

|  |  |
| --- | --- |
|  |  |

1. **Photon Transfer**

The photon transfer curve is a response from a CCD that is uniformly illuminated at different levels of light. It is plotted as the standard deviation against the average signal for a group of pixels contained on the CCD array. Data is plotted on log-log scale to cover the large dynamic range of the CCD. There are three distinct noise regimes in the plot

**Phase 1:** Read noise floor represents the random noise measured in totally dark condition, this is limited by the amplifier-noise.

**Phase 2:** Shot noise dominates as the illumination of CCD increases. Shot noise is associated with the random arrival of photons on the CCD. Some pixels intercept more photons than others, which accounts for the variance seen in pixel values. The uncertainty in the quantity of charge is proportional to the square root of the number of the number of incident photons.

**Phase 3:** This phase is associated with fixed-pattern noise that results from sensitivity differences among pixels. Pixel non-uniformity is a manifestation of processing variations when the CCD is fabricated. This problem generates pixels with difference responsivities. Pixel non-uniformity noise is proportional to signal.

A screenshot of a cell phone

Description automatically generated

The *abscissa* is proportional to the exposure period or the average number of incident photons and photo-generated charge per pixel elements.

Noise data are found by calculating the standard deviation of the pixels after the non-uniformity being removed by differencing, pixel by pixel, two identical images taken at the same exposure level. The *variance* of the differenced frame is given by the following formula, the factor of two is included as when two identical frames are subtracted or added, the random noise component of the resultant frame increases by the

* **Improvement**

In order to improve the statistics for photon transfer data, three or more exposure at the same signal level can be taken. is found by taking the average of the three mean level measured. The noise is determined by first differencing frames , then and lastly and generating three standard deviations. These values are then averaged together, yielding .