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Investigation of a possible physical mechanism for signal dependent charge sharing in CCDs

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Recent observations of significant nonlinearity in the observed noise statistics of Back Illuminated, deep depletion CCD sensors have been attributed to signal dependent charge sharing between pixels, after several more obvious explanatory possibilities have been eliminated. The sub-Poisson noise observed in these cases may be explained by a correlation between the amount of signal present in a pixel, and the likelihood of an arriving charge carrier to be diverted away from that pixel.

In this paper, we suggest and investigate a possible physical mechanism from which the observed correlation may arise. Using simplifying assumptions and analytical solutions of the potential and field distributions in the pixel, we show that differing potentials between neighbouring pixels (due to differing levels of collected charge) can lead to the effective sizes of pixels (as defined by the electric fields) changing. Using further simplifications, we present an approximate analytic expression for the effective pixel size which is dependent on pixel signal. Simple numerical simulations are presented which show that nonlinearity qualitatively similar to the observed results for CCD sensors can be produced by this model.

Finally, we obtain approximations for the probability distribution arising due to the model, from which mean and variance for given signal levels can be calculated. We show that the nonlinearity parameters extracted from these results are reasonably consistent with experiment.

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