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ON THE DARK CURRENT OF I-PentaMaxPro CAMERA

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The intensity of auroral emissions is typically rather weak and quite often the useful signal is comparable to the magnitude of the dark current of a registering device. In our installation, spectra are registered by IpentaMax camera with CCD and a microchannel image intensifier (1). To estimate the threshold sensitivity of the device one has to determine the noise characteristics of the camera, not provided in the technical documentation.

The basic sources of the noise signal in the camera are dark currents of the CCD and image intensifier. Examination of the camera dark current has been performed under the temperature of $+20 \div +23^0$ C, CCD temperature being -20^0C, with 30 s exposition and duration of sessions of 5 - 6 hrs.

1. Fluctuations of the dark current of CCD are considered to be a white noise with normal law distribution. The average magnitude of the current drops twice as CCD temperature decreases by 5^0 and constitutes ~20 electron/pixel s under -20^0 C. The thermostatic control system provides the accuracy of $\pm 0{,}05^0$C, that is why CCD dark current is stable in time. Fig.1, upper panel, presents temporal variations of the dark current averaged for the whole CCD (512x512 pxl) for three sessions. The variations do not exceed 1%.

2. The dark current of the camera (i.e. the CCD and intensifier) exhibits considerable variations with time, which depend on intensification magnitude (the lower panel of Fig.1; the numbers at the curves stand for chosen intensification). One can see that in most cases the dark current is getting stabilized for 2-3 hours, however, sometimes stability is not achieved even for 5 hours.

3. For spectral observations it is important to know both the value of the average dark current and its distribution over the CCD. Fig.2 presents dynamics of the dark current distribution averaged by CCD lines from 100 to 199, under maximum intensification of the camera. From the set of 600 shots we have picked every 12-th shot. It is obvious that the distribution shape is preserved under considerable variations of current magnitude.

4. Spatial resolution of the camera is determined by relationship between intensities registered in neighboring pixels, which can be revealed by presence of dark current correlation in those pixels. To perform correlation analysis we have randomly picked up 50 pixels with 6 pixels adjacent from the right, left, above and below. For all 50 pixel groups, chosen in such a manner from the data (similar to those presented in Fig.1), there were obtained time series and performed linear correlation for the dark current of CCD and camera. Fig.3 shows the correlation coefficient averaged over 50 pixel groups. This is the correlation coefficient of the intensity of the central pixel in a group with the intensities of the nearest ones from the right and left. One can see that there is no linear correlation with the neighboring pixel. The same is true when the pixels are adjacent from above and below.

5. For the camera (i.e. for CCD with intensifier) one should expect the presence of intensity correlation in the neighboring pixels. This is associated with electron scattering in the luminescent screen of the image intensifier, as the former has a finite thickness, and in result bigger scales of the light spot will be projected onto the adjacent pixels. Fig.4-6 show correlation curves for the same pixel groups as in Fig.3, but with the intensifier on, when intensifying G7, G8 and at the maximum intensification. The presence of correlation in the nearest pixels is confirmed, while the degree of correlation increases with intensification increasing.

6. The influence of small inhomogeneities of the camera dark current may be excluded, using the spectrograph capability to shift the spectrum, projected on the camera, by an arbitrary magnitude. The shift of the image is provided by the step-by step driver of the diffraction grid mechanism. Difference in signals with different positions of the spectrum would be equal to the difference in dark currents of the CCD (with the accuracy up to variations of signal itself).

Conclusions

1. The dark current of the CCD is stable in time.
2. The dark current of the camera (CCD + image intensifier) exhibits considerable variations, up to ~10%, which depend on the intensification.
3. The accuracy of absolute measurements of emission intensity is restricted by temporal instability of the camera dark current. To minimize the error, one needs keeping the camera on for a long period and frequent checking the dark current.
4. Specific inhomogeneities of spatial distribution of the camera dark current may be identified by means of shifting the registered image within CCD and finding the difference before and after shifting, which (within the accuracy of variation of the useful signal) is equal to the difference of dark current under consideration.
5. The accuracy of relative measurements of signal intensity (with taking into account conclusion 4) is restricted by statistic noise and can be increased by spatial averaging of the signal with simultaneous loss of spatial resolution.
6. The threshold spatial resolution of the camera is determined by the image intensifier and depends on the intensification magnitude.

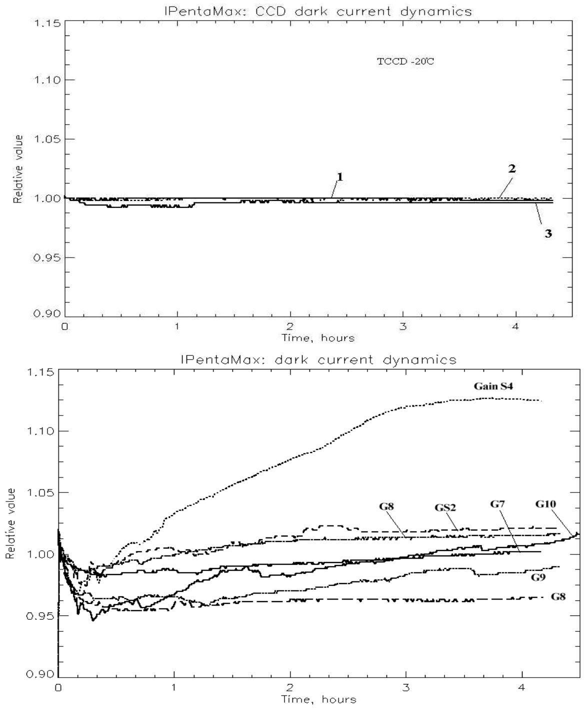

Fig. 1
Dark current dynamics
Upper panel: CCD alone
Lower panel: CCD + Image intensifier with different gain.

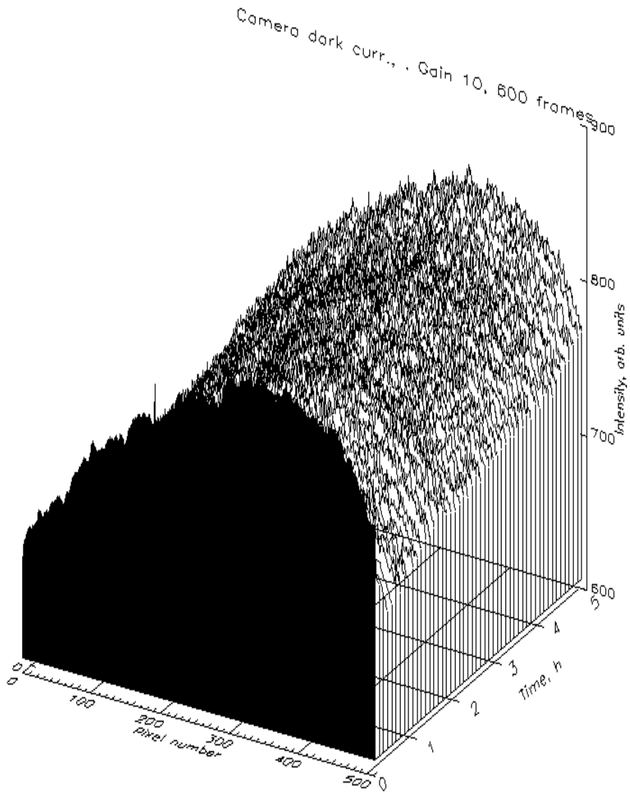

Fig. 2
Dynamics of camera dark current. Gain G10

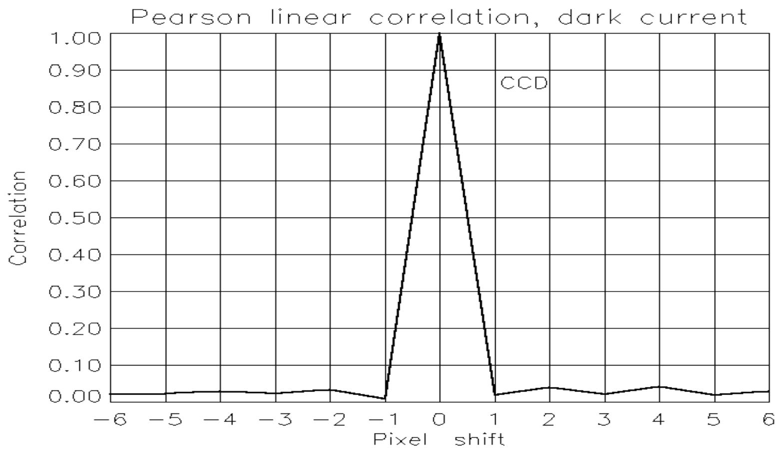

Fig. 3
Mean linear correlation of the noise in the randomly selected 50 groups of pixels. Image intensifier is turned off.

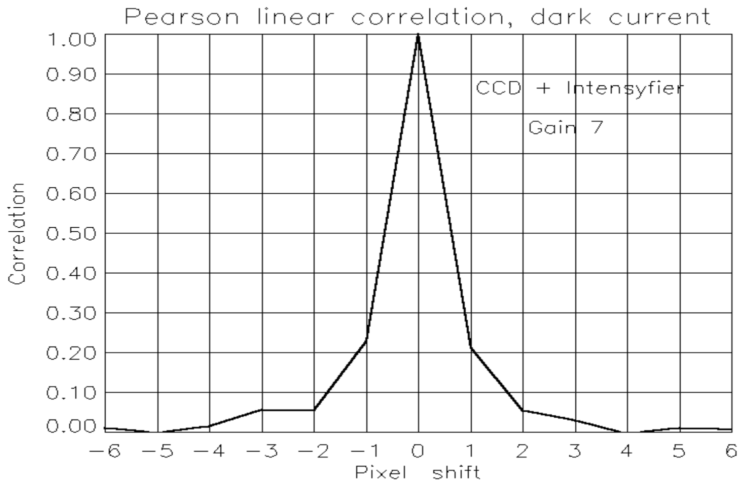

Fig. 4
Mean linear correlation of the noise in the randomly selected 50 groups of pixels. Image intensifier gain is 7.00.

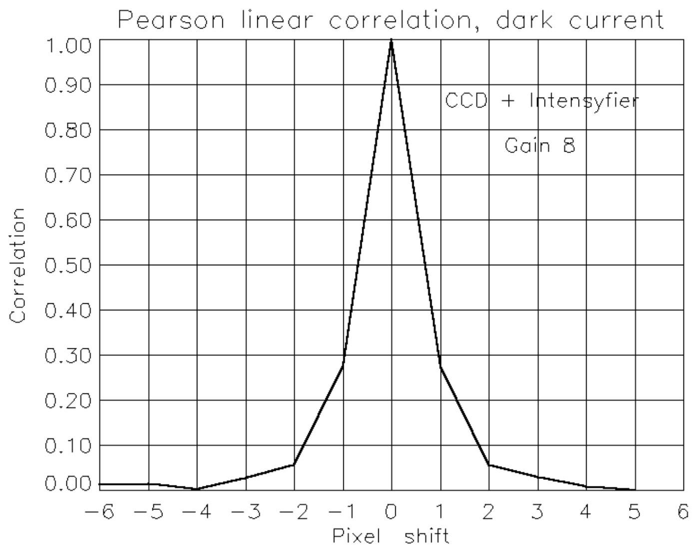

Fig. 5
Mean linear correlation of the noise in the randomly selected 50 groups of pixels. Image intensifier gain is 8.00.

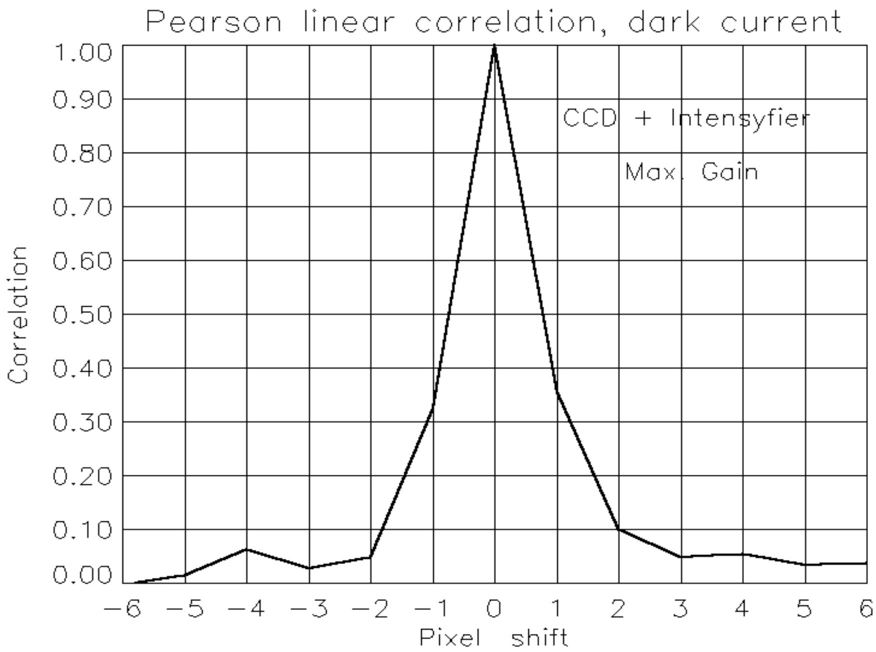

Fig. 6
Mean linear correlation of the noise in the randomly selected 50 groups of pixels. Image intensifier gain is 10.00.

Reference

1. Intensified PentaMAX system. Operational manual. Princeton Instruments, inc. 1997.