Estimating Phosphorescence Levels on IUE Spectra

Catherine L. Imhoff
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ABSTRACT: It is possible to compute how much phosphorescence will affect a given image due to the general phosphorescent background and also due to previous exposures and overexposures. We find that a heavy overexposure can contaminate long IUE exposures for several days.

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As many IUE users know, phosphorescence from previous exposures can affect IUE images. This can manifest itself in at least two different ways. First, the camera preparation sequence employs bright tungsten flood lamps, which cause a general phosphorescence all across the camera. This background must be taken into account when obtaining long exposures. Second, previous well-exposed or overexposed spectra produce phosphorescence on the camera in the region of the spectrum. This can make the subtraction of the background from the spectrum difficult, as when a high-dispersion "ghost" affects a low-dispersion spectrum. It can also produce a spurious signal in long exposures when weak spectra are expected; for instance, faint extragalactic spectra may be affected by a previous low-dispersion overexposure. These and other aspects of the phosphorescence have been discussed by Snijders (1983).

It is possible to calculate the effects of prior exposures on a given image. According to Coleman (1977, Camera Users' Guide, page 3-24), the camera phosphoresence behaves as the following:

$$I(t) = k\ E\ t^{-n},$$

where k and n are constants which differ somewhat from camera to camera, and E is the integrated intensity of the exciting exposure. E is assumed for simplicity to have occurred over a short period of time compared to t, which is the interval between the overexposure and the subsequent exposure. For convenience, we will consider intensities in units of DNs and time given in units of seconds.

Camera	k	n
LWP	1.2×10^{-4}	0.72
LWR	2.9×10^{-4}	0.77
SWP	1.8×10^{-4}	0.78

The superposition of the phosphorescence from the many camera preps done over the years has produced a more or less constant phosphorescence on the cameras of 5 to 10 DN/hour. The actual level depends mostly on the recent history of use of the camera. An XSPREP, performed after a heavily overexposed spectrum to remove the residual image from the camera target, floods the camera with an 8 times overexposure. This is followed with three fast scans, then a standard prep sequence. This process removes the residual image from the camera target, but also raises the phosphorescence all across the camera to roughly the 10 DN/hour level for several hours. If the camera has not been used for either exposures or camera preps for a couple of 8-hour shifts, the phosphorescence is likely to be low, perhaps 5 DN/hour. The rates at various locations on the camera differ, with higher phosphorescence in regions of higher sensitivity and lower phosphorescence in areas of lower sensitivity.

Exposure time estimates for long exposures must take into account this general phosphorescent background. For instance, one might have computed the expected ultraviolet fluxes for a particular object. Using the sensitivity curves given in the IUE Observing Guide (Sonneborn et al. 1987), the optimum SWP exposure time is calculate to be 7.0 hours to produce a signal of 200 DN, or an "intensity" of 28.6 DN/hr. If one includes the pedestal of 25 DN and phosphorescent background of roughly 8 DN/hr, then the best exposure time is is smaller.

220 DN	=	25 DN	+ 8 DN/hr x T	+ 28.6 DN/hr x T
(peak signal)		(pedestal)	(phosphorescence)	(signal)

Solving for T, the best exposure time is computed to be 5.3 hours.

It is possible to estimate the rate of phosphorescence due to a previous overexposure for a particular image using the equation and values given above. For example, I have evaluated the two possible sources of phosphorescence that could have affected a recent Guest Observer's spectrum. This particular image, which was a 14-hour exposure on the SWP in low dispersion, was affected by the phosphorescence of a previous high-dispersion image. There were two suspects: first, a single 100-times overexposure taken about 24 hours before the start of the GO's 14-hour exposure, and second, several optimum spectra taken in rapid succession just prior to the start of the 14-hour exposure. (An optimum spectrum is defined to be one with a peak signal of 220 DN. Thus a spectrum that reaches 250 DN is 1.14 times overexposed.)

The high-dispersion image which was a 100-times overexposure occurred about 24 hours before the GO's 14-hour exposure. Then E = 220 DN * 100 = 22,000 DN. After 24 hours (86400 sec), just prior to the 14-hour exposure,

$$I(t) = 1.8 \times 10^{-4} \, (22000) \, (86400)^{-0.78}, \text{ or}$$

$$I(t) = 5.59 \times 10^{-4} \text{ DN/sec.}$$

By the end of the GO's 14-hour exposure, the phosphorescence will have diminished somewhat:

$$I(t) = 1.8 \times 10^{-4} \, (22000) \, (136800)^{-0.78}, \text{ or}$$

$$I(t) = 3.90 \times 10^{-4} \text{ DN/sec.}$$

For simplicity, we can use the mean of these two values to calculate the resulting phosphorescence. Then over the 14-hour exposure, 24 DN would have accumulated due to phosphorescence from the previous 100 times overexposure!

The second possible source of phosphorescence was the set of several optimum spectra taken just prior to the 14-hour exposure. For simplicity assume that there were 8 such spectra spaced apart by 1 hour each. Then at the beginning of the 14-hour exposure, the phosphorescence would have been

$$\text{Sum } I(t) = 1.8 \times 10^{-4} (220) * (3600)^{-0.78} *$$

$$(1^{-0.78} + 2^{-0.78} + \ldots + 7^{-0.78} + 8^{-0.78}), \text{ or}$$

$$I(t) = 2.20 \times 10^{-4} \text{ DN/sec.}$$

By the end of the 14-hour exposure, the phosphorescence will have dropped off rapidly to

$$I(t) = 5.79 \times 10^{-5} \text{ DN/sec.}$$

So on the average this source of phosphorescence will have contributed only about 5 DN to the 14 hour exposure, much less than the 100-times overexposure 24 hours before.

These calculations indicate that it will be 8 days before the phosphorescence from the 100-times overexposure will be down to a rate of 5 DN over 14 hours. However Snijders (1983) notes that over long time scales the phosphorescence is less than predicted by the equation. Still, such a heavy overexposure is likely to affect long exposures taken over the next several days. Thus it is wise to avoid overexposing the cameras when possible to minimize the effects on other observers.

References:

Sonneborn, G., Oliversen, N. A., Imhoff, C. L., Pitts, R. E., and Holm, A. V. 1987, NASA IUE Newsletter No. 32, pg. 1.

Snijders, M. A. J. 1983, NASA IUE Newsletter No. 23, pg. 56 (also ESA IUE Newsletter No. 16, pg. 10).