IUE DATA REDUCTION

XIII. Modification of Photometric Correction to Extrapolate the Intensity Transfer Function

1. Introduction

A memorandum distributed to Guest Observers by A. V. Holm and recently reprinted in NASA IUE Newsletter 7 called attention to the errors in photometry which can arise because of the way in which the IUESIPS photometric correction program FICOR5 truncates the output flux number (FN) values for pixels with input DN values which exceed the corresponding maximum DN values in the intensity transfer function (ITF). The purpose of the present memo is to announce and describe a recently-implemented software modification (program FICOR6) which reduces these and other photometric errors by an extrapolation of the ITF.

2. Properties of the Upper ITF Levels

The ITF for each camera is comprised of a concatenation of averaged, geometrically corrected flat field exposures. The memo by Holm presented approximate DN values of the highest exposures in the ITF, in tabular form as a function of wavelength, in the vicinity of the low dispersion orders for each camera. These values were measured on printouts of 12 X 12 pixel averages of the DN values in the highest level for each ITF. Holm's measurements demonstrated that truncation error was potentially greatest for $\lambda \lesssim$ 1350 Å in SWP low dispersion and for $\lambda \gtrsim$ 2900 Å in LWR low dispersion, since for these wavelength regions the maximum DN levels in the ITF's were less than 220 DN. More precise measurements, obtained with computer extraction techniques much like those used to extract ordinary IUE spectra, have recently been made and will be presented in the next NASA IUE Newsletter.

3. Previous Photometric Correction Method: FICOR5

The photometric correction program FICOR5 in use until 10 January 1980 performed a simple linear interpolation for DN within the ITF tables to assign the corresponding FN value for each pixel. Pixels which are below-range (DN < lowest level of ITF) were assigned negative FN values by linear extrapolation back from the first two points of the ITF, but pixels which are above-range (DN > highest level of ITF $\equiv DN_{max}$) were truncated to FN_{max}, the FN value of the highest level. See Figure 1. Although this truncation is described in previous documentation (CSC TM-77/6250 "IUE Image Processing Overview and Mathematical Description"), the magnitude of the potential truncation errors at certain wavelengths has only been recently appreciated (Holm memo). Plans are underway to increase DN_{max} in the areas of both camera tubes where it is currently least by adding higher exposure levels to the ITF's for SWP and LWR.

For SWP, FN_{max} (as defined in Figure 1) is 17632; for LWR, FN_{max} is 25220. Saturated pixels (DN=255) are assigned FN values of 32767.

An additional problem with the simple point-to-point linear interpolation done by FICOR5 occurred when the DN values in the ITF reach the saturation value (DN=255). When this occurs, DN within the range just below saturation were in most instances improperly transformed to FN since the DN in the ITF have been artificially limited to 255. Refer to Figure 2.

4. New Photometric Correction Method: FICOR6

Since 5:00 GMT on 10 January 1980 the program FICOR6 has been used to perform the photometric correction of all IUE images. FICOR6 changes the way FN values are assigned in the two special cases where FICOR5 was in error, through linear extrapolation of the ITF. In all other cases, including "below range" pixels, FICOR6 operates identically to FICOR5. Improvement in photometric accuracy results from the use of FICOR6; further improvement will be realized when higher ITF levels are added.

Case A - Extrapolation Beyond End of Unsaturated ITF

If $DN > DN_{max}$, an improved FN value is returned in FICOR6 by extrapolating past the end of the ITF; see Figure 1.

The extrapolation is linear, with a slope defined by the last two points in the ITF. The extrapolated FN value, FN_{extrap}, is greater than the FN_{max} value used in FICOR5 but is limited to a maximum value of 32767 (maximum halfword integer value), which is also the FN value assigned to saturated pixels (DN=255). In the future reduction era planned to begin in several months' time (see IUE Data Reduction memo V1 in NASA IUE Newsletter 6), even saturated pixels will be allowed to assume extrapolated FN values up to some maximum value, but under the present reduction system they are still set to 32767 in order to allow flagging. Hence, an FN value of 32767 can result from either a saturated input or an unsaturated extrapolation limited by the halfword integer format; both are flagged in the same way by the ϵ field, and both appear with the "+" symbol on CalComp plots. The keys on the plots have been modified to identify the "+" symbol as either "saturated, or limited extrapolation".

Case B - Extrapolation Within a Saturated ITF

The new program FICOR6 improves the photometry in cases when the ITF is saturated by assigning FN values by linear extrapolation from the two highest unsaturated points in the ITF; see Figure 2. This method calculates a better slope for the ITF in the affected region and returns FN values which are normally less than the corresponding FN values returned by FICOR5.

The detailed ITF measurements which will be presented in next NASA IUE Newsletter document those regions of the SWP and LWR low dispersion spectra subject to the inaccurate intensity transformation of this type previously made by FICOR5. These regions, where $DN_{max}=255$ in the ITF, are the long wavelengths of SWP and the short wavelengths of LWR (low dispersion in each case).

5. A Sample Comparison of the Old and New Methods

In Figure 3 a comparison is made of spectra reduced using FICOR5 and FICOR6. The spectra shown are extracted from LWR 1349, an 8 second exposure of θ^1 C Ori, which was selected because it exceeded the LWR ITF exposures at some wavelengths. Note that in the region of heaviest exposure the FN returned by FICOR6 are greater than the FN returned by FICOR5: at these wavelengths, extrapolation beyond the end of the unsaturated LWR ITF is performed. For this particular exposure, the FICOR6 FN values which have been extrapolated are up to ~ 15 percent larger than the truncated FICOR5 FN values. Note that at lower exposure levels, FICOR5 and FICOR6 give identifical results.

6. Identification of Old and New Methods

Apart from using the effective date of 10 January 1980 to identify use of the new program FICOR6, Guest Observers may verify which photometric correction version was used to reduce any given spectrum by means of the image processing history portion of the image label. Spectra reduced with FICOR5 bear that inscription, whereas spectra reduced using FICOR6 are so marked.

B. Turnrose
C. Harvel
R. Bohlin

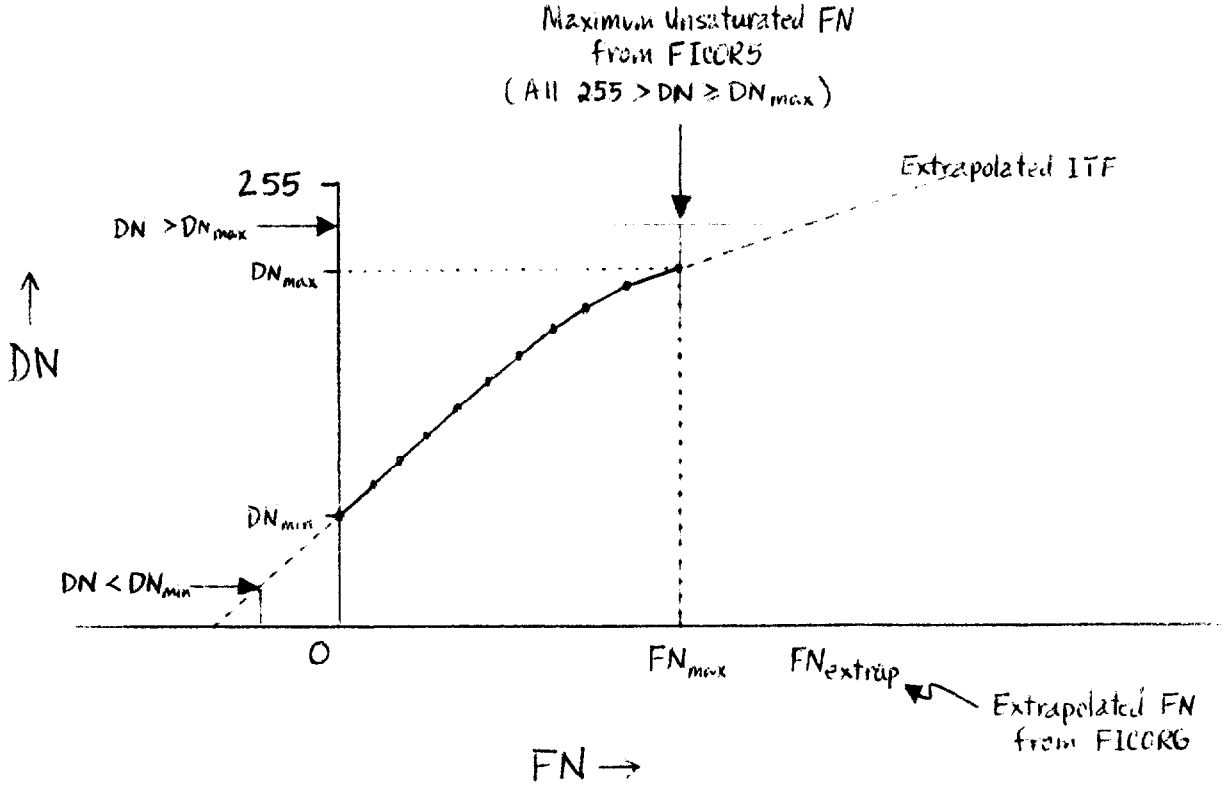

Figure 1. Difference in calculation of FN for 255>DN ≥ DNmax in FICOR5 and FICOR6.

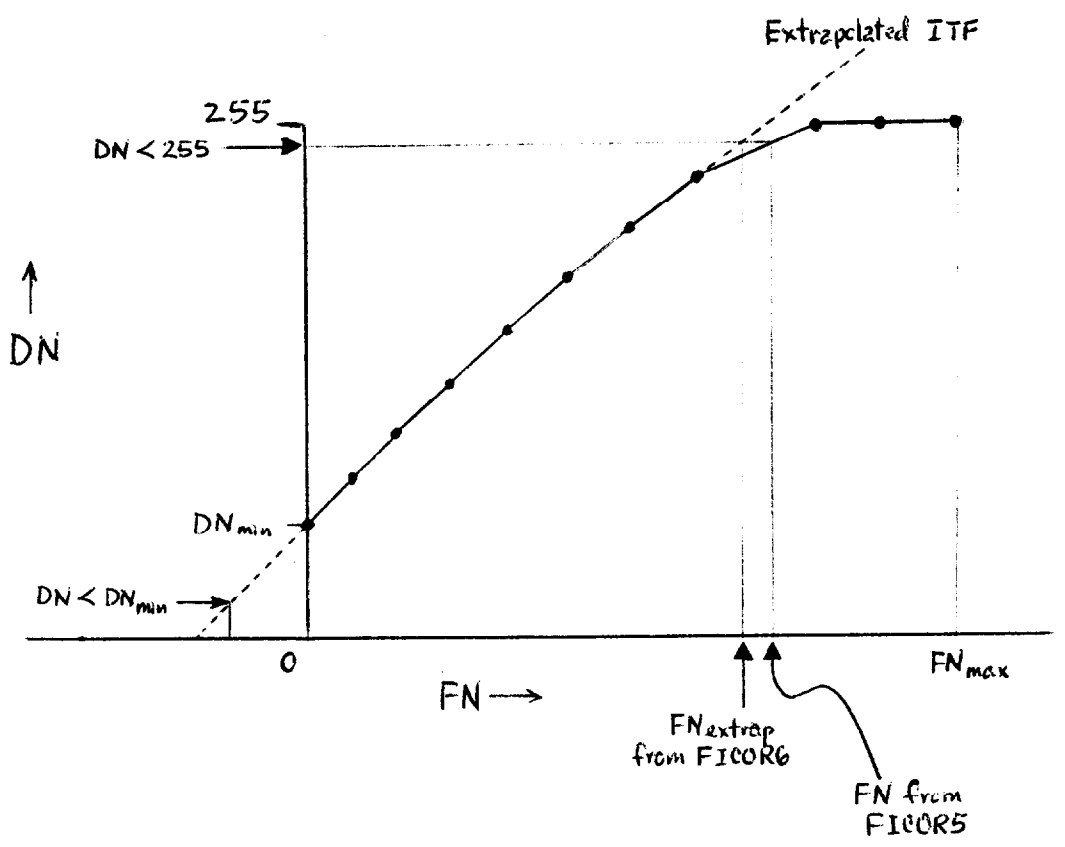

Figure 2. Difference in FICOR5 & FICOR6 calculation of FN for large DN when ITF is saturated.

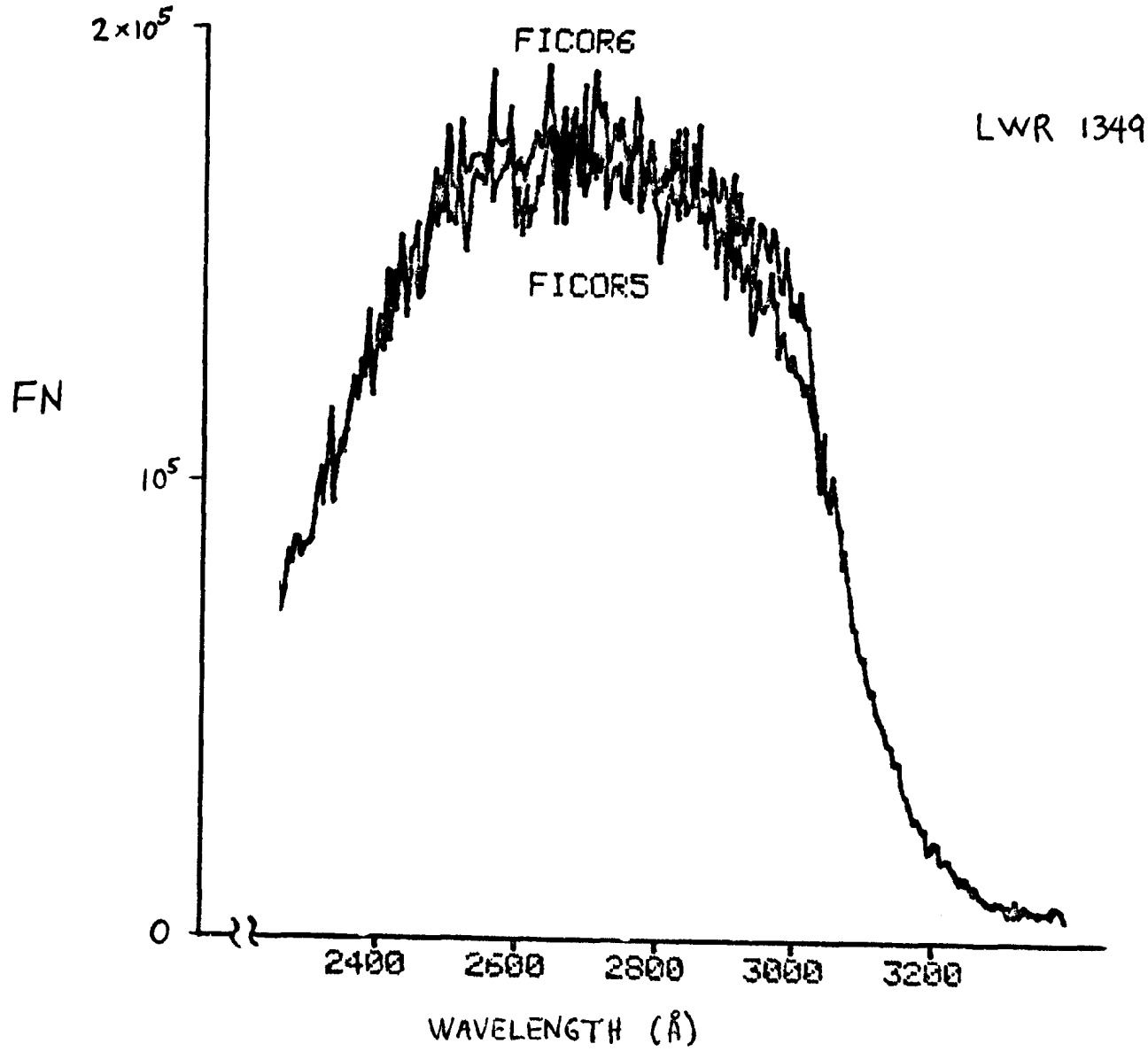

Figure 3. Portions of extracted gross spectra of LWR 1349, comparing effects of FICOR5 vs. FICOR6.