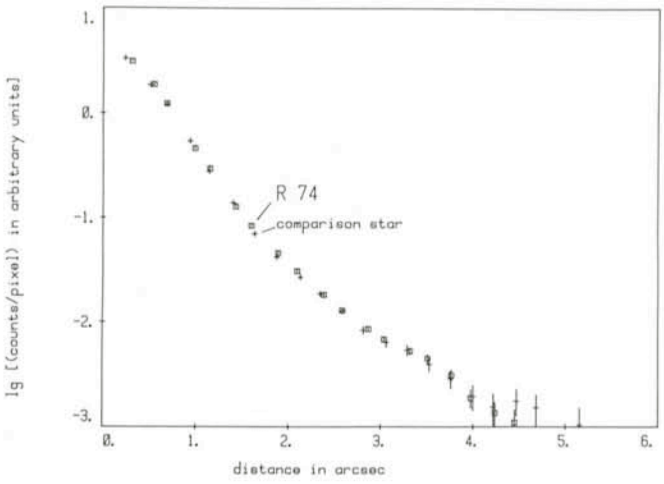

Fig. 6: *Radial brightness profiles of R 74 and a nearby comparison star. The seeing was 1.2 arcsec (FWHM), as in Fig. 4. The profile of the image of R 74 shows no significant deviations from the profile of the comparison star which is supposed to be the point-spread function, i.e. the profile of a point source.*

1.5 m telescope, and 3 nights in January 1984 were allotted to this project.

The weather at La Silla is known to be excellent in January with 90% of photometric nights. This means that about 3 nights in January are not photometric. Unfortunately, it happened that we got these 3 nights; therefore, a calibration of the images was not possible. So we decided to take photographs in one filter – H_α – only, since a determination of line ratios was not possible. In addition, it was a matter of good luck to get properly exposed images, with all these clouds passing. Therefore, we obtained much less useful data than we had anticipated. Useful data of 15 stars have been recorded, but the exposure levels of several pictures is far from ideal.

The analysis of the data is illustrated in Figs. 2, 3, 4 and 5. Fig. 2 shows the field around the S Dor variable R 127 after subtraction of the electronic bias and flat-field correction. Fig. 3 shows the same field in the form of an isocontour plot. In the next step we cleaned the surroundings of the star and an appropriate comparison star – in this case R 128 – from nearby stars by subtracting a properly scaled and centred stellar profile. The cleaned image is shown in Fig. 4. Finally, we determined the radial brightness profile of the star and the comparison star in order to look for a possible extension of the stellar image. The results for R 127 and R 128 are shown in Fig. 5. The curve of R 128 has been shifted to match R 127 in the inner parts. There is a pronounced difference in the two profiles between about 1.5 and 4 arcsecs which we identify with a nebula surrounding R 127.

R 127 has received much interest in recent years. Walborn (1982) described the spectrum as intermediate between Of and WN stars and found velocity-doubled nebular lines. Stahl et al. (1983) detected an S Dor-type outburst of the star, which was also reported in the *Messenger* (Wolf and Stahl, 1983). In addition, Stahl et al. detected nebular emission lines in R 127 B which gave evidence for a spatially resolved emission-line region. Very recently, Lund and Ferlet (1984) reported broad NaI D absorption-line features which they ascribed to an old, cool, ejected shell. It may well be that it is this shell which we see on our direct photographs. Assuming that the nebula is expanding with the velocity indicated by the NaI D absorptions and using a radius of 3 arcsecs, we estimate a kinematic age of about 15,000 years for the nebula around the star.

On most of our other photographs we see little evidence for nebulosities around the stars. As an example we show in Fig. 5 the data for the P Cyg star R 74. We have found, however, extended structures around a few more stars (although in no case as obvious as in the case of R 127). But in these cases it is not clear if the extension of the images is due to a nebula or to nearby unresolved stars. As usual, more observations are needed.

We thank the ESO staff for technical assistance. Comments from Claus Leitherer on the manuscript are gratefully acknowledged.

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A Possible Nonlinearity in IDS Data

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I. Introduction

Most of the users of the Image Dissector Scanners mounted on the Boller & Chivens Cassegrain spectrographs on La Silla will be aware of the high count rate nonlinearity of the IDS. The typical figure for this saturation effect is a 10 per cent loss at count rates in excess of some 2,000 detected events per channel per second. For a linear dispersion of 1.7 Å per channel (171 Å per mm grating) this corresponds to a 10 mag star at the 3.6 m and an 8 mag star at the 1.5 m telescopes. In the following I will report on another nonlinearity effect present at very low light levels, i.e. for count rates below 100 counts per second and channel, and discuss some of the possible sources and implications.

II. The Observed Nonlinearity

During the process of the analysis and interpretation of a large number of high signal-to-noise IDS spectra of H II regions I have been confronted with the inconsistency of observed values and theoretical predictions for emission line ratios. The line ratios concerned are: [O III] λ5007 versus λ4959, [N II] λ6583 versus λ6548 and the Balmer series from Hα to H12. The two forbidden line ratios are expected to lie around 2.9 (see for example the compilation of C. Mendoza in "Planetary Nebulae", IAU Symposium No. 103, ed. D.R. Flower, p. 143 [1983]). My own data and those of other ESO observers are centred around 3.15 with a sigma of 0.1. It is clear that errors in the reddening corrections, flat fielding and response calibration cannot be made responsible for this discrepancy. Saturation would decrease the observed line ratios rather than enhancing the stronger lines with respect to the fainter ones. In a detailed analysis of my own data and a large number (> 500) of published observations I demonstrate that the true intensity ratio of the above forbidden lines is likely to be around 3.03 (± 0.03) (to be submitted). Under the assumption of a power law nonlinearity (see below) an index of 0.96 is appropriate to bring the ESO IDS data into agreement with this "true" value for the line ratios.

The Balmer line ratios are affected by interstellar extinction and will obviously suffer from any mismatch between the *absolute* calibration of blue and red spectral ranges as well as any low frequency shift in the spectral response function of the instrument. However, a large fraction of my data has sufficient signal to noise in order to measure the Balmer lines up to H 12. A simultaneous solution of the amount of reddening (using different reddening curves) for all the line ratios available shows that, whatever choices are made, a perfect solution (within the statistical errors) can only be made under the assumption that the stronger lines are enhanced with respect to the fainter ones. A typical example is shown in Table 1 for spectra of the 30 Dor nebula. The first row contains the theoretical values of the Balmer decrements for case B, a density of 100 and an electron temperature of 10,000 K. The second row displays the best solution obtained by giving H3/H4, H5/H4 and H6/H4 the highest weigths and using the extinction curve of Savage and Mathis (*Ann. Rev. Astron. Astrophys.*, **17**, 73, 1979). The last row shows the solution obtained by assuming a power law nonlinearity with index 0.96 under the same choices as above. It is clear that this is scratching uncertainties in the few per cent range and can only be used as an additional indication for nonlinearity effects.

TABLE 1:

Line ratio H	3/4	5/4	6/4	9/4	10/4	11/4	12/4	[O III]
Theory	2.86	.469	.259	.073	.053	.040	.031	3.03
C (Hβ) = 0.80	2.78	.457	.250	.065	.040	.035	.040	3.21
C (Hβ) = 0.70 corr. for nonlinearity	2.82	.460	.256	.070	.044	.038	.043	3.07

Comparison of theoretical Balmer line ratios and of the line ratio [O III] 5007/4959 with observations. The overall agreement is better if the data are corrected for nonlinearity effects. Balmer line decrements 7/4 and 8/4 are affected by blends with strong forbidden lines, H12 is hard to resolve.

I will not go into more detail in this note but rather summarize my findings. There seems to be a nonlinearity in spectrophotometric data obtained with the IDS detectors at both the 3.6 m and the 1.5 m telescopes. This nonlinearity *increases* the measured intensity ratio of emission lines over the one inherent in the source spectra. The effect occurs at very low light levels, long before nonlinearities due to saturation are important. It seems not to depend on the absolute strength of the signal over a wide range of fluxes (10^{-11} to 10^{-15} erg/sec/cm^2/Å). The effect is present in the raw data and a careful check of the IHAP reduction routines has been made to verify the linearity in the data reduction. The correction formula I suggest to apply to the raw data prior to all reduction is:

$$I(\lambda)/I(\lambda_o) = [i(\lambda)/i(\lambda_o)]^{(0.96 \pm 0.02)}$$

where "i" is the measured intensity (or count rate) and "I" the corrected one. Since it is not clear in which way the nonlinearity works (losses for low count rates or gains for higher count rates) the absolute value of the intensity remains undetermined. Needless to say that observers should check their data before applying this correction blindly.

III. Possible Sources of the Nonlinearity

Since the nonlinearity seems to be inherent in the IDS raw data it is interesting to see whether or not the ESO IDS detectors are peculiar among similar instruments. The above-mentioned analysis of the [O III] line ratios suggests that similar detectors, i.e. the KPNO IIDS, the Lick Observatory ITS, the AAT IIDS and intensified Reticon systems are affected by the same sort of nonlinearity to various degrees. To mention a specific example: In a recent paper J. B. Kaler (1985, preprint Astron. Dept. Univ. of Illinois at Urbana) reports line ratios for 12 planetary nebulae observed with the Red Reticon System at KPNO. The average reddening corrected line intensities are 3.17 for [O III] and 0.43 for H5/H4. Compared with the theoretical values 3.03 and 0.47 respectively and supposing the same power law nonlinearity, an index of 0.91 can be derived.

In order to prove that the nonlinearity is not depending on the absolute value of the signal, I have used He-Ar spectra taken through different neutral density filters, kindly provided by S. Cristiani and G. Palumbo. A straightforeward result is the fact that the exposures can be scaled linearly into each other for count rates between 35 and 0.03 detected counts per second per channel, that is equivalent to the range 60,000 to 50 in IDS data values. A check on the power law nonlinearity is however impossible with these data since it would require the knowledge of very precise values for the attenuation of the neutral density filters or for line ratios in the He-Ar spectra. Similarly, a test in the laboratory would have to record independently the illumination of the photocathode over a dynamic range of at least 100 with an accuracy of better than 5 per cent. The illumination would also have to be comparable to the astronomical reality, i.e. a few photons per second per channel at the photocathode with a high spatial contrast.

Possible sources for the nonlinearity can be sought in the fact that the combination of a three-stage intensifier chain with an image dissector is not working in pulse-counting mode. The principle is to read the temporal buffer (phosphor) at repeated times and accumulate the detected phosphor photons in the memory. The length of this acquisition interval is 1 microsecond and acquisition is repeated for the same location on the phosphor every 4.2 milliseconds. The delta impulses of the photoelectrons released at the first photocathode are broadened considerably in the intensifier chain. The output pulse has a decay law of the form "rate(t) = const. × 1/t" and about 50 per cent of the phosphor output photons are released within 5 milliseconds. Up to this stage the whole process is essentially a convolution of several Poissonian processes, i.e. arrival of photons, release of photoelectrons, particular gain of the intensifiers for each photoelectron and emission of phosphor photons. However, the IDS is sensitive enough to record a given phosphor pulse *on the average* 3.3 times. At this stage one of the requirements for a Poissonian process is violated, i.e. the probability to detect an event at time n × t is coupled with the probability to detect it at (n–1) × t. Another violation of the ideal counter can be seen in the existence of a discriminator level that is intentionally set to suppress counts from the background (intensifier shot noise, scattered light) and consequently rejects the faint end of the photon event distribution. Furthermore one has to expect the occurrence of aliasing between the sampling frequencies 10^6 cps and 238 cps and the high and low frequency components in the Poissonian distributed input signal. Readers interested in the system performance of intensified IDS detectors are referred to the papers of McNall, Robinson and Wampler (*Publ.A.S.P.*, 82, 488, 1970), Robinson and Wampler (*Publ.A.S.P.*, **84,** 161, 1972), McNall (*Publ.A.S.P.*, **84,** 182, 1972) and Cullum (*ESO Technical Report* No. **11,** 1979).

IV. Implications

At first glance the nonlinearity reported here seems to have little importance for the average observation. Error estimates quoted for line ratios measured in H II region spectra and in the absolute flux calibration are usually of the order of 10 per cent or larger. However, these error estimates concern the random errors. The power law nonlinearity reported here will produce a systematical deviation of 17 per cent for intensity ratios of 100 and 9 per cent for intensity ratios of 10. Though this might be negligible for observations of continuum sources, the effects on H II region line spectra are far reaching. For an electron temperature of 10,000 K and a density of 100 electrons per cubic centimetre the intrinsic ratio of the [O III] lines 5007/4363 is 170. The observed ratio will be 210 and a temperature of 9,350 K will be derived. Together with the overestimated ratios of the strong oxygen lines over Hβ an oxygen abundance too high by a factor of two or more will result. This systematic effect will be present in investigations based on large samples of H II regions or planetary nebulae—for example in abundance gradient studies.

Last but not least I would very much appreciate any comments, in particular to know about similar findings with the detectors on La Silla or anywhere else. The growing confidence in the reality of the nonlinearity reported here has benefitted by discussions with a large number of observers, engineers, technicians and theoreticians, who deserve my thanks.

The Local Stellar Environment (LSE) — The B Emission-Line Stars

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Observations made during the last decade outside the visual region—in the X-ray, far UV, far IR, and radio regions—have profoundly modified our understanding of the LSE. Historically, from only visual observations, the LSE was considered as either the locale of protostellar material surrounding stars in their early evolutionary stages, or as a product of mass ejection during only the late stages of stellar evolution. However, we know from all these new observations that a mass outflow is observed from a variety of stars, during a variety of evolutionary stages, all across the HR diagram; and that there exists a continuous interaction between the mass outflow at a given epoch, and either (i) the general ISM; (ii) the prestellar nebula; or (iii) the mass outflow at a preceding epoch, i.e. a self-interacting variable mass outflow. Thus, the picture of a static LSE enveloping a thermally structured star is replaced by a dynamic LSE enveloping a nonthermally structured star in continuous interaction with the LSE. From this viewpoint, the outermost layers of the star are to be considered as a major component of the local environment; and the structure of both the outermost layers and the local environment reflects the properties of the mass flux. For this reason, progress in our understanding of the LSE is intimately linked to progress in understanding stellar atmospheric structure and stellar evolution.

The LSE may be either observed directly as nebulosity whose association with star(s) in its vicinity has been established; or inferred from the presence of spectroscopic features that imply the existence of an extended atmosphere. Examples of an observed LSE are: (a) pre-main-sequence (PMS) stars, identified by Herbig (1960), still embedded in the primeval nebulosity—Herbig Ae, Be, T Tauri—(b) the planetary nebulae which, on the contrary, have manufactured their own local environment, and represent late stages of stellar evolution. Examples of inferred LSE come from the presence of low-excitation/ionization emission lines (relative to photospheric conditions) such as observed in the visual spectrum of Be and P Cygni stars. These are to be contrasted with chromospheric-coronal, high-ionization emission lines, such as seen in the Sun and in WR stars. Low-ionization emission, especially in the Balmer lines, implies, for these hot stars, the existence of an extended, cool, outer atmosphere. Our understandig of each of these types of stars, whose LSE is observed or inferred, has strongly evolved during the last decade. But, undoubtedly, it is for the Be stars that our picture has changed the most. Be stars are probably the best observed objects in the Galaxy, after the Sun. In the same way as the Sun has served as a guide for understanding stellar chromospheres and coronae, Be stars may help us to understand that broad class of emission-line objects, observed across the whole HR diagram, which, in addition to having hot, rapidly expanding regions, also possess cool, extended, low-velocity regions which define their peculiarity.

I. The Be Stars as Seen in the Visible— A Variable, Cool, Extended Outer Atmosphere

Be stars show a B-type spectrum of luminosity class III-V accompanied, in the visible region, by emission in the Balmer lines, and often in the singly ionized metallic lines whose presence is expected only at later spectral types.

The origin of emission lines in B-type spectra was attributed by Struve, in 1931, to the presence of an extended, cool atmosphere. The question to be answered, at that epoch, by the existence of Be stars was: Why do only some stars of the B-type class possess an extended atmosphere? On the basis of observed line widths, interpreted as rotational, Struve hypothesized that the presence of emission lines in the spectrum and the rapid rotation of the star were two connected phenomena. At that epoch, rotation at break-up velocity was believed to produce equatorial mass ejection. Thus, a star rotating at such velocity would form an extended, cool, rotating, equatorial gaseous disk. This was the model of Be stars proposed by Struve. Subsequent studies showing that v. sini values are higher, statistically, for Be stars than for normal Bs, strengthened this picture.

However, it was realized that critical rotation by itself could not produce a mass ejection. Moreover, the observations did not provide any basis for justifying the assumption of critical rotation for these stars. Finally, it was recognized that v. sini