Examples of Qualitative Interpretation

This section deals with the Hα line profile of HR 5999, and with different types of qualitative interpretation for a type III P Cygni profile. We will discuss four examples, which should be considered as incomplete. In particular, these explanations are all based on a spherically symmetric atmosphere. A whole set of different interpretations can probably be found without this assumption.

A first possibility for obtaining a type III P Cygni profile is to assume that the line is formed in a region of the extended atmosphere, which is subject to both differential rotation (rotational velocity decreasing outwards) and an expansion (expansion velocity increasing outwards). This idea was first presented by Mihalas and Conti (1980) to explain such profiles. In this case, a "normal" P Cygni profile is "dug" in the, due to rotation, double-peaked emission profile. A profile like the one shown in Fig. 1 can be formed if the maximum expansion velocity v_{max} is lower than the rotational velocity.

Another possibility that can be considered is that the line is formed in a region containing a chromosphere which is surrounded by a cool decelerating wind. In this case a P Cygni profile is "dug" in the single peak emission profile formed in the chromosphere. It is possible to obtain a profile of the expected shape if outward or inward velocity fields are present in the chromosphere.

The same kind of profile can be produced if a cool expanding envelope surrounds a hot region where high velocity turbulent motions or organized motions (e.g. loops) are present. In this case the maximum expansion velocity of the cool envelope must be lower than the velocity of the motions in the hot region.

As a fourth possibility we suggest that the line is formed in a geometrically thin expanding or infalling shell. It has been shown by Wagenblast, Bertout and Bastian (1983) that a profile of the same shape as the one shown in Figure 1 can be obtained provided certain conditions on the velocity law, the source function and the absorption coefficient are fulfilled.

These four examples show that interpreting a line profile such as the Hα line in HR 5999 is complicated, and that the solution is probably not unique. Since the projected rotational velocity of HR 5999 is fairly high (180 km s^{-1}), since the star is surrounded by a chromosphere and transition region (Tjin A Djie et al. 1982), and since Hα is the major signature of the presence of a stellar wind (but with v_{max} near 100 km s^{-1} it is smaller than the stellar v. sin i), the first three possibilities should certainly be analyzed quantitatively. Note that it is not likely that Hα is optically thin in HR 5999. However, as the star is variable in this line, a spherically symmetric model is certainly not sufficient.

Concluding Remarks

The Hα-line profile varies in HR 5999 on three characteristic time scales: hourly, nightly and monthly. In HD 163296 only the last two time scales have been observed so far. Both stars are A-type presumably very young objects. As in T Tauri stars, the cause of the spectroscopic variations is still unknown. Whether it is intrinsic to the stars (activity phenomena) or extrinsic (phenomena affecting the circumstellar envelope) is still to be investigated.

References

Allen, D.A. Swings, J.-P.: 1976, *Astron. Astrophys.* **47,** 393.
Beals, C.: 1950, *Publ. Dom. Astrophys. Obs.* **9,** 1.
Buscombe, W.: 1969, *Mon. Not. R. Astr. Soc.* **144,** 31.
Finkenzeller, V., Mundt, R.: 1984, *Astron. Astrophys. Suppl.* **55,** 109.
Herbig, G.H.: 1960, *Astroph. J. Suppl.* **6,** 337.
Kuhi, L.V., 1964, *Astroph. J.* **140,** 1409.
Kuhi, L.V., 1978, in *Protostars and Planets,* ed. T. Gehrels, Tucson, Univ. of Arizona Press, p. 708.
Mihalas, D., Conti, P.S., 1980, *Astroph. J.* **235,** 515.
Strom, S.E., Strom, K.M., Yost, J., Carrasco, L., Grasdalan, G.: 1972, *Astroph. J.* **173,** 353.
Thé, P.S., Tjin A Djie, H.R.E., Brown, A., Catala, C., Doazan, V., Linsky, J.L., Mewe, R., Praderie, F., Talavera, A., Zwaan, C.: 1985a, *Irish Astronomical Journal,* in press.
Thé, P.S., Felenbok, P., Cuypers, H., Tjin A Djie, H.R.E.: 1985b, *Astron. Astrophys.,* in press.
Tjin A Djie, H.R.E., Thé, P.S., Hack, M., Selvelli, P.L.: 1982, *Astron. Astrophys.* **106,** 98.
Wagenblast, R., Bertout, C., Bastian, V.: 1983, *Astron. Astrophys.* **120,** 6.
Wilson, R.E., Joy, A.H.: 1952, *Astroph. J.* **115,** 157.

The Photometric Capabilities of the IDS System

E.J. Wampler, ESO

In the early days of the IDS development crude tests of the system indicated that its response was approximately linear with intensity (McNall, Robinson and Wampler, *Pub. A.S.P.* **82,** 488, 1970; C.M. Gaskell; J.A. Baldwin, private communication). In the March 1985 issue of the *Messenger* (No. 39, p. 15) M. Rosa pointed out that the response of the IDS system depended on the intensity of the input light source. The correction formula that he gives in his article is equivalent to stating that the output signal of the IDS has the following dependence on the input light intensity:

$$[\text{Signal}] = [\text{intensity}]^{1.04 \pm 0.02}. \quad (1)$$

This result was obtained by comparing the observed to the theoretical intensities of the [OIII] λλ 4959,5007 doublet and the relative intensities of lines in the Balmer series.

In March 1984 Kris Davidson reached an identical conclusion. In a letter to R.J. Dufour (private communication) he described his study of the intensity ratio of the [OIII] λλ 4959,5007 doublet together with laboratory experiments using neutral density filters, and emission line lamps together with continuum lamps. The result of this study was that the intensity was related to the signal by an identical formula to that given above. The only difference was that Davidson gave ± 0.01 as the error of measurement.

Finally, as part of a program to determine the luminosities of bright quasars, Wampler and Ponz (*Ap.J.* **298,** XXX, 1985) compared IDS magnitudes with those obtained by O. Eggen (*Ap.J. Suppl.* **16,** 97, 1968). They found that over a 5 magnitude range in intensities a 0.2 magnitude correction to the IDS data was needed in order to get agreement with the Eggen photomultiplier data. This 0.2 magnitude correction is exactly what would be needed if the relationship between signal and intensity were given by formula 1. Thus the reality of the nonlinearity seems to be very well established and the value of the power law exponent seems to be well determined.

This non-linear response explains why the IDS sometimes gives poor sky cancellation even when very high signal-to-noise ratios are achieved. If ϱ is the ratio of the input photon rate from the sky to the rate from the star and if R is the ratio of the observed star signal to the signal that would have been observed in the absence of a sky background then clearly

$$R = (1 + \varrho)^{1.04} - \varrho^{1.04}. \quad (2)$$

This reduces to

$$R \approx 1.04\, \varrho^{0.04} \quad (3)$$

if $\varrho \gg 1$, and similarly, if $\varrho \ll 1$ then,

$$R \approx 1 + \varrho\,[1.04 - \varrho^{0.04}]. \quad (4)$$

Strong night sky emission lines will leave a positive residual that can be quite large unless the star signal is also very strong. In addition, emission line intensities in the star signal will be slightly overestimated if there is a strong sky or star continuum background.

Besides the non-linearity in the system response as a function of intensity there is a non-linearity to the system response as a function of time. The output signal of the IDS increases with increasing exposure time. This was first noted by P.M. Rybski (*Bull. A.A.S.* **12,** 751, 1980). According to Rybski the phenomenon is repeatable and intensity independent. Thus it is possible to avoid the most serious errors by adopting proper observing procedures. Wills, Netzer, and Wills (*Ap. J.* **288,** 94, 1985) describe one such technique in the appendix to their paper on broad emission features in quasars. It is clear that if the integration periods used on the program objects are significantly greater than the integration periods used for standard stars, the program stars may appear systematically brighter than they actually are by a few tenths of a magnitude. In any case very short exposure times on the standard stars should be avoided.

The causes of these non-linearities are unknown to me. As Rybski (*Bull. A.A.S.* **12,** 751, 1980) has pointed out, a model with an exponential decay and a power law increase approximately fits his data. Deviations from this simple model might account for the effect seen in the non-linearity of response of the detector to different input light intensities. One could speculate that metastable states in the phosphor screen increase the efficiency of the phosphor as the input photoelectron flux increases. Clearly all detector systems that work by measuring the intensity of the phosphor screens of image tubes might be expected to show similar response characteristics.

The effects listed above are important at the 5 %–20 % level but they can be corrected to the 1 % level. With care, and with proper attention to the standard star calibration it should be possible to obtain absolute spectrophotometry accurate to a few percent with the IDS system.

I would like to thank Peter Shaver and Michael Rosa for their suggestions and help in improving this note.

Rotational Velocity of F-type Stars

G. Noci[1], S. Ortolani[2] and A. Pomilia[1]

[1] Istituto di Astronomia, Università di Firenze
[2] Osservatorio Astronomico di Asiago

The rotation is a general property of celestial objects, which is probably generated by the vorticity of the interstellar matter. Obviously, stars forming from turbulent vortices conserve some of the initial angular momentum, depending on the early formation history. It is well known that there is a well-determined trend of the rotational velocity of main sequence and giant stars with the spectral type. This is shown by the continuous and dashed curves of Figure 1, which are from the paper of Bernacca and Perinotto (*A.A.,* **33,** 443, 1974). Early-type stars have high rotational velocities, while late-type stars are slow rotators. There is a sharp drop in the velocities from F0 to F5, particularly for main sequence stars: stars later than F5 have all very little angular momentum. This has been attributed to the presence of planets around late-type stars, which would contain most of the angular momentum of the system, as it happens in the case of the solar system. The angular momentum is probably transferred during the T Tauri pre-main-sequence phase. Another possibility suggested for the rotation velocity drop is the loss of angular momentum caused by stellar winds, which should occur for stars having convective layers close to the surface, i.e. late-type stars.

Hence the study of the stellar rotation is of great importance in astrophysics and, in particular, in the study of planetary formation. Recent studies show that fast and slow rotators differ also in other properties. It appears (Pallavicini et al., *Ap.J.,* **248,** 279, 1981) that G to M type stars have the rotational velocity proportional to the X-ray luminosity, while for early-type stars there is no such correlation, but rather a correlation between X-ray luminosity and bolometric luminosity.

In the case of late-type stars, the superficial magnetic fields, which are thought to be the cause of the X-ray emission in these stars, are due to a dynamo process which depends on the rotational velocity. F-type stars are important because at this type there must be the transition to a different mechanism

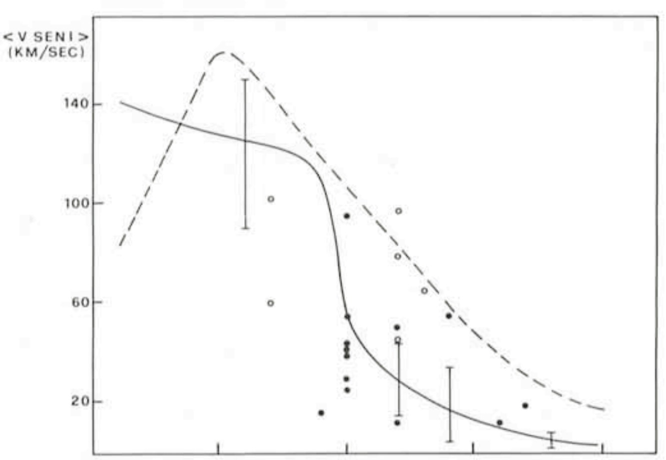

Figure 1: *Rotational velocity vs. spectral type. The continuous and dashed curves (for main sequence and giant stars) are taken from Bernacca and Perinotto (1974). Open circles: giant stars. Filled points: main sequence stars.*