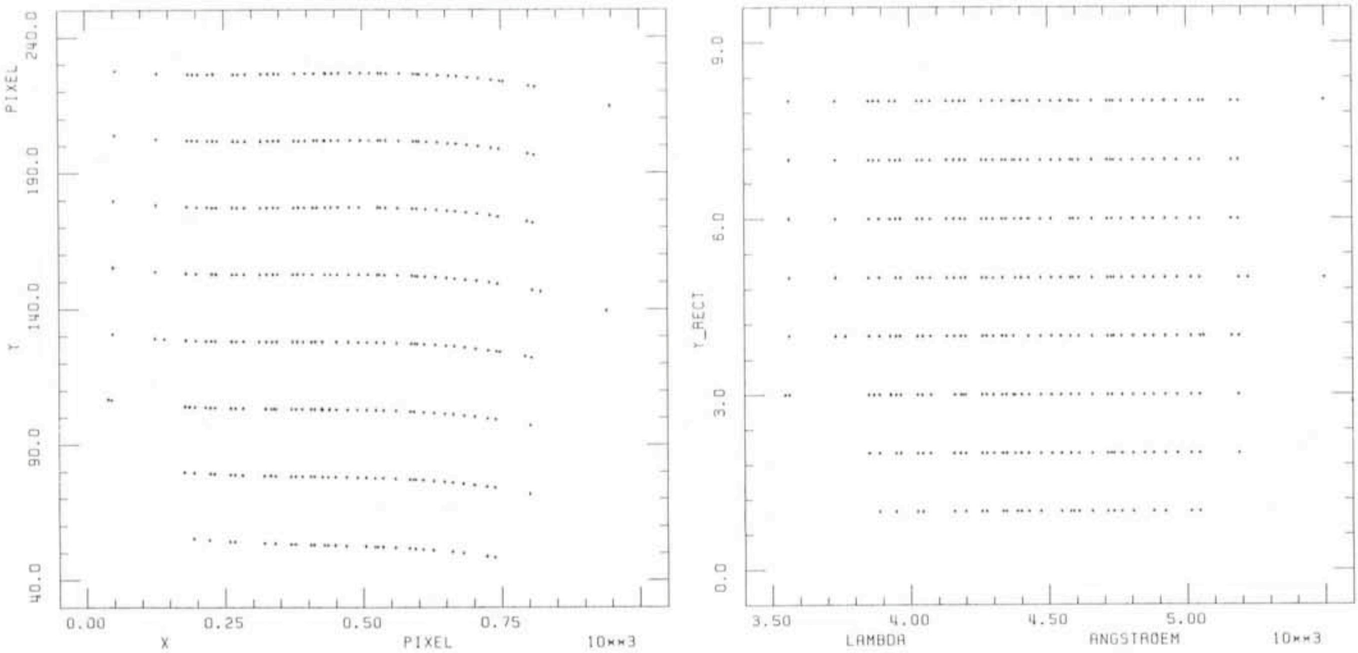

Figures 1 a and b: *The positions of the stronger arc lines (a) in the raw data and (b) after the simultaneous geometrical rectification and rebinning to wavelength. (In Figure 1 a the vertical and horizontal scales are different in order to enhance the visibility of the distortion. The step size in y has been changed from Figure 1 a to b; this is of no relevance.)*

batch task to be executed only at night time. This can be conveniently done, since once reseaux marks and/or comparison spectra are correctly identified, no further user intervention is necessary.

We have written this short note about the reduction of PCD data within MIDAS in order to inform PCD observers about this new possibility to treat their data. We furthermore believe that it is a good example of the growing maturity of MIDAS because more and more problems can now be treated by simply using MIDAS as a high-level problem solving language, often without having to do any FORTRAN coding. After some further improvements have been included, the software described will be available to the MIDAS users community.

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Variations of the High Resolution Hα-line Profiles of the Very Young Stars: HR 5999 and HD 163296

P. S. Thé and H. R. E. Tjin A Djie, Astronomical Institute, Amsterdam
C. Catala, F. Praderie and P. Felenbok, Observatoire de Paris, Meudon

Introduction

It was recognized long ago that the Hα line (6563 Å) is very important for the study of stellar winds in pre-main sequence (PMS) stars (Kuhi 1964). There are two reasons for this. Firstly, the Hα line is usually the most intense emission line in the visible spectrum of PMS stars. It is expected to be formed in an extended region of the wind, thus providing a good global insight tool on the structure of the wind. Secondly, the location of the Hα line in the optical spectrum is such that this line can be very easily observed with Reticon and CCD detectors.

Two southern emission-line stars, HR 5999 and HD 163296, drew much attention lately because these bright A-type objects possess most of the spectacular properties of the so-called Herbig Ae/Be stars (Thé et al. 1985a and Thé et al. 1985b). This class of Herbig (1960) stars was shown by Strom et al. (1972) to consist of younger than main-sequence objects.

In the present short communication the remarkable variations of the Hα profile in HR 5999 during a space/ground-based coordinated campaign in September 1983, and at other epochs, will be discussed. The emission line star HD 163296, originally intended as a comparison star, was also observed at the same observing runs as HR 5999; its Hα profile variation will be shown as well. Suggestions for an interpretation of the Hα-line formation are then presented.

Some Properties of the Hα line in PMS Stars

Finkenzeller and Mundt (1984) have surveyed 57 candidate Herbig Ae/Be stars in the line of Hα, NaI D and HeIλ5876. They conclude that the Herbig Ae/Be stars can be devided in 3 subclasses according to the shape of the Hα-line profile: (1) with a double peak, comprising 50 % of the whole sample; (2) with a single peak (25 %), and (3) with a P Cygni profile (20 %).

A similar survey was reported for T Tauri stars by Kuhi

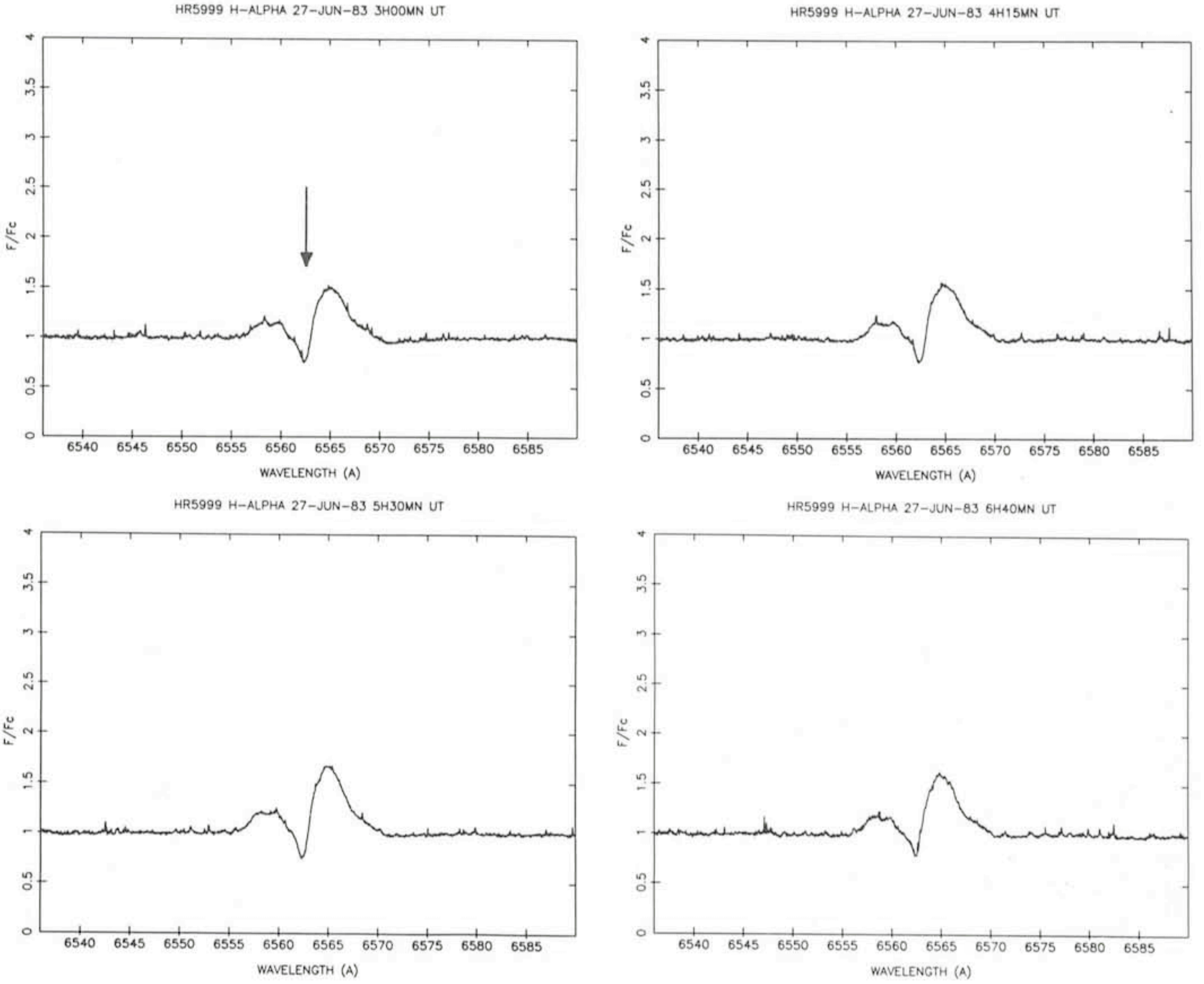

Figure 1: *The Hα line of HR 5999 at four different moments on June 27, 1983. The wavelength scale is in the geocentric frame. The vertical arrow on the first spectrum indicates the absorption trough.*

(1978). Compared to Herbig Ae/Be stars, the T Tauri stars are spectroscopically more difficult to observe in high resolution mode because they are fainter. For this reason 20 % of the 75 stars surveyed by Kuhi (1978) have been inadequately observed for the purpose of an Hα line classification. Among the 75 program stars 60 % have a double peak at Hα, 10 % a single peak, 5 % a P Cygni profile and 5 % a profile with a longward displaced absorption (this could indicate infall of matter). No inverse P Cygni profile has been observed in the Hα line of T Tauri stars.

The basic property that appears from these surveys is that most of the PMS stars show a double peak profile at Hα. However, significant fractions of the observed samples exhibit different kinds of profiles, suggesting that there may exist important differences in the geometry and/or the structure of the extended gaseous envelopes of the two sets of PMS stars. An important question to be addressed is whether these differences correspond to different evolutionary stages.

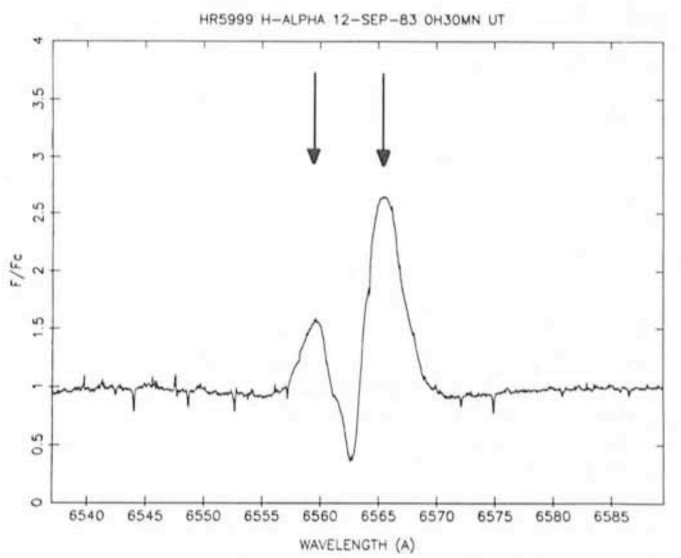

Figure 2: *The same as in Figure 1, but for the September 12, 1983, spectrum. Note that the y-axis scale is the same as in Figure 1. The two vertical arrows indicate the blue and the red emission components.*

Observations of HR 5999 and HD 163296

The star HR 5999 (A7 IIIe, V = $6\overset{m}{.}8$) was observed with the Coudé Echelle Spectrometer fed by the 1.4 m Coudé Auxiliary Telescope (CAT) at ESO. The detector is a cooled Reticon chip

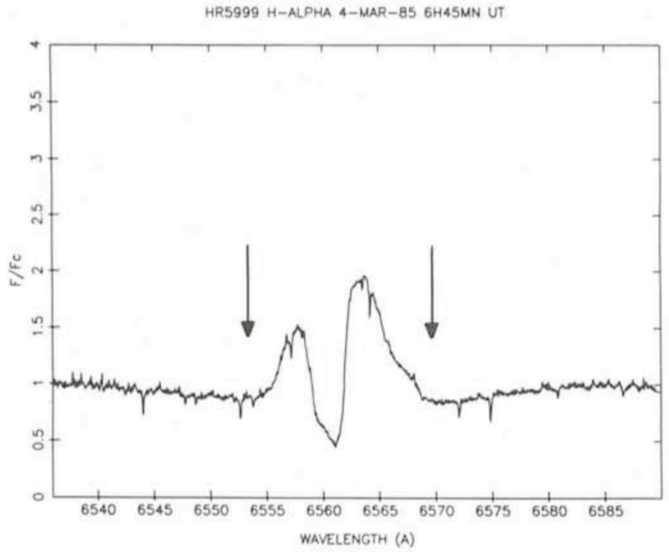

Figure 3: *The same as in Figure 1, but for one of the March 1985 spectra. The two vertical arrows indicate the limits of the emission.*

with 1872 diodes. These high resolution observations were made on June 27, 1983, by P. S. Thé, on September 12, 1983, by R. Faraggiana and on March 3 to 9, 1984, by F. Praderie. They obtained 5, 1 and 10 spectra, respectively, with exposure times of 1 hour or more. An attempt to observe the Hα line simultaneously with the EXOSAT (September 11, 1983, 16–21 hr UT) from the South African Astronomical Observatory (74 inch telescope, image tube spectrograph equipped with a Reticon, resolution 594 mÅ) was totally unsuccessful due to poor weather conditions (F. Praderie, J. W. Menzies).

The spectra obtained at ESO were reduced on the Meudon Observatory VAX computer using the STII interactive software. They are normalized to the continuum. Figure 1 displays four Hα line profiles of HR 5999 observed during one night in June 1983, Figure 2 the profile obtained in September 1983, and Figure 3 one of the spectra observed in March 1985. The hourly variations, the night-to-night as well as the long-term variations (3 and 20 months) of the Hα profile of HR 5999 are not dramatic, although they are more than significant. The global shape of the line remains unchanged, namely a double-peak emission with higher red than blue intensity and an absorption component of which the minimum lies well below the continuum level. This kind of profile is similar to the classical type III P Cygni profile, according to Beals' (1951) classification.

On the June 1983 spectra (Fig. 1) one notes the progressive development of a weak absorption on the blue emission peak of Hα. This feature is absent in September 1983. Furthermore, in September 1983, the two emission components are more intense than in June 1983, and the ratio I_{Red}/I_{Blue} has increased. In March 1985, the absorption trough is much broader and deeper, the emission components are still more intense than in June 1983. The night-to-night variation that we have observed in March 1985 will be described and discussed in a future publication.

It is also remarkable that the wind velocity in the line of sight at large distances from the stellar surface is no more than about 100 km s^{-1}, as indicated by the positional shift of the blue absorption trough in the profile.

The $V = 6^{m}.7$ emission line star HD 163296, classified "almost conventional Be" by Allen and Swings (1976), B9 V by Buscombe (1969), A2e by Wilson and Joy (1952), was observed by the same persons using the same instruments and resolution as HR 5999 in June and in September 1983. Figure 4 shows the Hα profiles of HD 163296. The change in profile between the two dates (monthly variations) is impressive. The Hα line shows a type I or II P Cygni profile, with 3 blue absorption components in September 1983, while it was a double-peak emission profile in June; in the blue absorption component(s) the intensity is below the continuum level. The June 1983 profile is somewhat similar to the Hα profile of HR 5999. It should be noted, that a recent (March 1985) IUE observation of the MgII lines of HD 163296 shows the same behavior compared to an old spectrum found in the IUE data bank.

These remarkable long-term variabilities, in particular the fact that a single star can shift from one Hα profile shape to another, argues against the interpretation of the different profile shapes being characteristic of different evolutionary stages. However, HD 163296 does not seem to be a typical Herbig star, because it is not associated with a nebulosity (Thé et al. 1985b), so that no general conclusion about the whole class can be drawn from this result.

It is of interest to understand what kind of atmospheric structure produces these different Hα profiles and their variations.

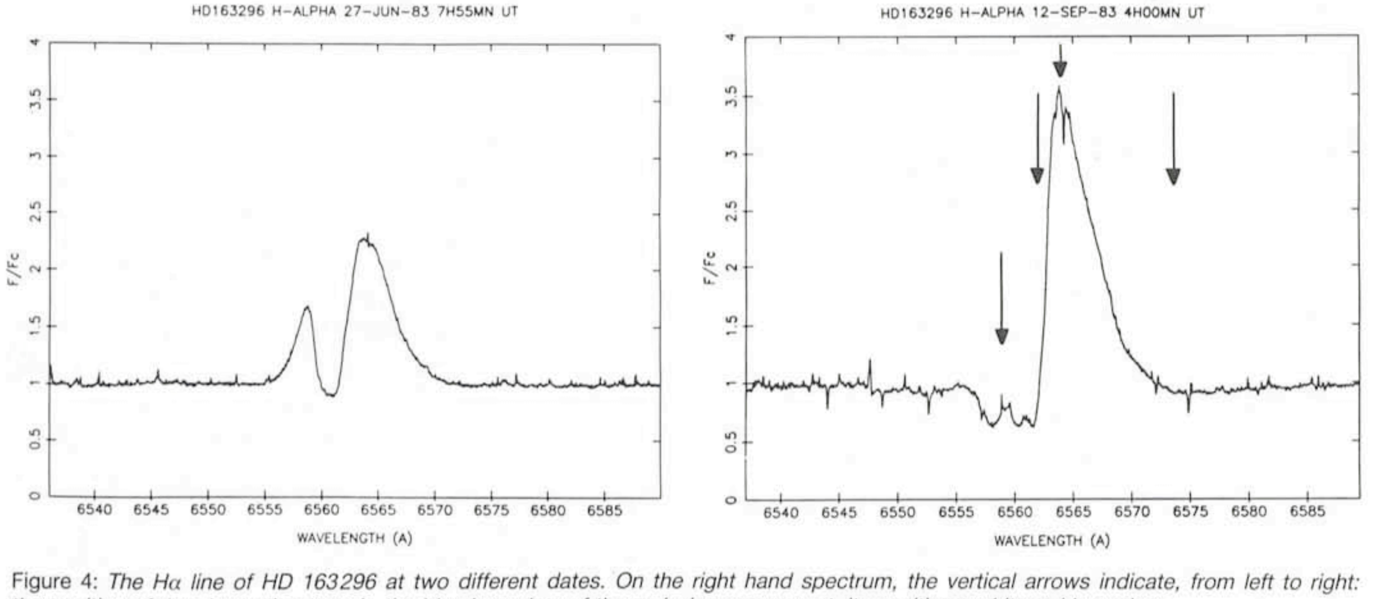

Figure 4: *The Hα line of HD 163296 at two different dates. On the right hand spectrum, the vertical arrows indicate, from left to right: the position of the absorption trough, the blue boundary of the emission component, its position and its red boundary.*

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.

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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:

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

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 non-linearity seems to be very well established and the value of the