TABLE 1: *Sun-Earth-Comet constellation during the observing periods of comet P/Tempel 2 at ESO La Silla*

Date	r (AU)	Δ (AU)	ϑ (o)	α (o)	γ (o)	ESO telescope
4.5.1988	1.94	0.99	152	14	48	2.2 m
18. – 24.7.1988	1.53 – 1.50	0.79	115 – 111	37 – 39	291 – 288	1.5 m Danish
30.10. – 2.11.1988	1.46 – 1.47	1.22 – 1.24	81	42	258	1.5 m ESO
3. – 10.11.1988	1.47 – 1.50	1.24 – 1.31	81 – 80	41 – 40	258 – 256	GPO

r = solar distance of the comet; Δ = Earth distance of the comet; ϑ = Sun-Earth-Comet angle; α = Sun-Comet-Earth angle or phase angle; γ = position angle of the Sun (measured east of north).

spectral range of the Swan bands. However, this would be fulfilled only if there is no exchange of populations between the lowest vibrational levels. Such transitions are indeed forbidden, because the C_2 is homonuclear and one can expect that the ratio of the integrated band fluxes and consequently also the vibrational temperature would be constant and independent on the heliocentric distance. But the observational results obtained for many comets indicate that T_{vib} is systematically lower than T_b. This effect can be explained by a sophisticated model developed by Krishna Swamy and O'Dell in the past decades (1987). They propose a mechanism which allows transitions between triplet state and adjacent lowest singlet state via a cascade-like radiation process.

Due to this process low values of T_{vib} should be derived from the observed flux ratios of the Swan bands. Since the probability of the downward spontaneous transitions is independent of the radiation density, while the upward induced transitions are proportional to the photon flux, the effect of the downward transitions into singlet states becomes more dominant if the radiation field decreases. Thus the apparent T_{vib} decreases with increasing heliocentric distance. Because the relative strength of the ($\Delta v = +1$) band increases with T_{vib}, the flux ratio of ($\Delta v = +1$)/($\Delta v = 0$) is a function of the heliocentric distance.

Ratios of the integrated fluxes of these bands are primarily determined by the rate at which transitions occur between the lowest electronic triplet state forming the Swan bands and the lowest singlet level.

The transition probability between these two states (denoted for simplicity as a-X) is unknown, but can be assumed as a free parameter. In Figure 4, the full lines represent the dependence of the integrated flux ratio of ($\Delta v = +1$)/($\Delta v = 0$) Swan bands on the heliocentric distance, theoretically predicted by Krishna Swamy and O'Dell (1987) for various values of the transition moment $(Re)^2$ expressed in atomic units. The filled circles indicate the most precise values of the flux ratios obtained by O'Dell et al. (1988) for comet P/Halley. Symbols V indicate data obtained from comet P/Halley with high spatial resolution onboard the spacecraft VEGA 2 (Vanysek et al., 1988). V_o stands for the impact parameter (i.e. minimal distance of the line of sight from the nucleus) < 1000 km and V the same for 2500 km.

Our preliminary result for the ($\Delta v = +1$)/($\Delta v = 0$) flux ratio of C_2 in comet P/Tempel 2, marked by symbol T in Figure 4, falls between data for comet P/Halley. Hence the most probable value of the transition moment seems to be about $2.5\ 10^{-6}$ and the corresponding Einstein coefficient for the downward spontaneous transition to be about $7\ 10^{-3}\ s^{-1}$.

Since the C_2 molecules can be formed either in the singlet and/or in the triplet state, the time required for establishing the triplet/singlet equilibrium would be several hundred seconds and the vibrational temperature would be time-dependent. Immediately after the C_2 formation which occurs in the innermost part of the coma, the vibrational temperature should be high and close to the colour temperature of the Sun, but during the expansion of the C_2 molecules into space, the populations in the lower states become redistributed and T_{vib} as well as the relative flux of the ($\Delta v = +1$) band decreases. This effect seems to be confirmed by VEGA 2 data obtained for comet P/Halley.

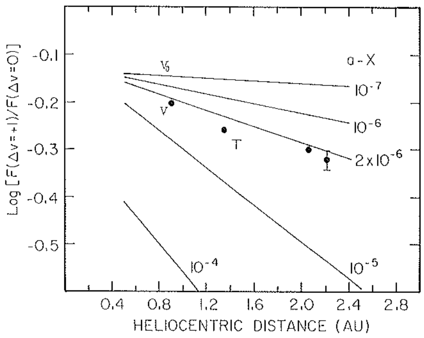

Figure 4: *The dependence of flux ratio C_2 ($\Delta v = +1$)/($\Delta v = 0$) on the heliocentric distance. Full lines represent theoretical model calculations for various values of the electronic moment, derived by Krishna Swamy and O'Dell. Full circles are measurements of comet Halley, symbol T for comet P/Tempel 2. V_o and V represent the average value obtained from Vega 2 spectrograms of P/Halley (for details, see text).*

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Spectral Analysis of A-F Giant Stars

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1. Introduction

A very large variety of stars of spectral type A-F display abundance anomalies: metallic-line stars, magnetic stars, λ Bootis, . . .

These stars are best distinguished from normal stars by means of photometry. Two photometric systems are especially well adapted to this effect: the uvbyβ and Geneva systems. A description of the latter has been given in

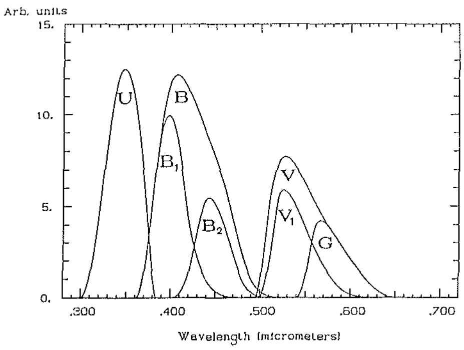


Figure 1: *Responses for the seven colours of the Geneva photometric system to an equiphotonic flux. The determination of these profile are from Rufener and Nicolet (1988).*

the *Messenger* by Rufener (1983). The spectral response of the seven filters used (Rufener and Nicolet, 1988) is given in Figure 1.

The metallic-line stars, or Am stars, were the first to be studied at depth in the Geneva system and all their photometric properties are to be found in Hauck and Curchod (1980). The temperature parameter used for the Am stars is the B2-V1 index, while d = (U-B1) − 1.430 (B1-B2) and m_2 = (B1-B2) − 0.457 (B2-V1) are the parameters for luminosity and blanketing respectively. An important parameter is that of metallicity, Δm_2, being the difference between m_2 observed and m_2 for the Hyades at the same B2-V1 value. The average Δm_2 values are -0.009 ± 0.011 for the AV stars, 0.002 ± 0.011 for the mild Am and 0.013 ± 0.019 for the classical Am stars. We have known for more than a quarter of a century (Van't Veer, 1963) that the Am stars show an overabundance of iron and a calcium and scandium deficiency. Those stars for which [Fe/H] values have been determined confirm the relation between [Fe/H] and Δm_2 obtained by Hauck et al. (1985) for main sequence stars.

If Δm_2 is considered to be a parameter for segregating the Am from the normal stars, an attempt may be made to use it for detecting stars of this type which would not have been considered by spectroscopists. Only six main sequence stars were found by Hauck and Curchod (1980) with a Δm_2 value $\geq$ 0.015 and classified as main sequence stars. On the other hand, several stars in luminosity class III showed a high Δm_2 value.

2. Metallicity Among A and F Giant Stars

Both spectroscopic and photometric observations confirm that the Am stars are considered to be main sequence stars. However, a small number of them belong to higher luminosity classes (IV and III), and this has been clearly confirmed by a number of studies (Burkhart et al. 1980, Van't Veer et al. 1985, Smith 1971, Faraggiana and Van't Veer 1971, Stickland 1972). Furthermore, another kind of star with a metallic line spectrum similar to that of Am stars belongs to the luminosity classes IV and III: the δ Delphini stars.

A systematic study of A-F spectral type stars with luminosity class III was recently carried out by Hauck (1986). By using an additional photometric criterion, $\Delta d \geq 0.10$, 132 stars could be considered as giants on a spectroscopic and photometric basis. During the study of their photometric properties, a very high proportion (36 %) was found to have a Δm_2 value of ≥ 0.015. However, before concluding that nearly one third of the giants exhibit a high [Fe/H] value, it should be ascertained that there also exists a relation between [Fe/H] and Δm_2 values for these stars. Unfortunately, only six of them belong to the Cayrel et al. (1988) catalogue, and even though their [Fe/H] and Δm_2 values seem to be in good agreement with the relation established for the dwarf stars, this number is too low to draw a valid conclusion. It is for this reason that a campaign for the abundance determinations of giant A-F stars has been undertaken. This study should not only enable a better understanding of the significance of Δm_2 for the A-F giant stars, but also attempt to understand the surface abundance pattern of the evolved stars. Are these giants, with a high Δm_2, evolved Am stars or are they δ Delphini stars that have not been noticed by spectroscopists? Is there an evolutionary sequence between all these categories?

A first series of spectra was obtained at Kitt Peak by Abt and Hauck in 1985 and Berthet (1989) has recently published the results of an analysis of five observed stars.

3. Observations and Data Reduction

At Kitt Peak, Abt and Hauck used the coudé spectrograph of the 2.1-m telescope. The data were obtained with a CCD camera at a reciprocal dispersion of 9.9 Å/mm in the spectral region 4400–5100 Å. The analysis of these observations was very interesting, and at the same time, at the end of 1987, the 1.52-m ESO telescope was being upgraded in having the Echelec spectrograph equipped with a CCD detector at the coudé focus. The announced performances (Alloin et al. 1987 and Gilliote et al. 1987) of this new equipment and the results from the Kitt Peak spectra induced us to undertake an observing programme to increase our sample of A-F giant star spectra. In September 1988, we obtained for our programme of spectroscopic study of A-F giant stars five nights with this new equipment at La Silla. Thus observations were carried out with the 1.52-m telescope and the Echelec spectrograph working with a

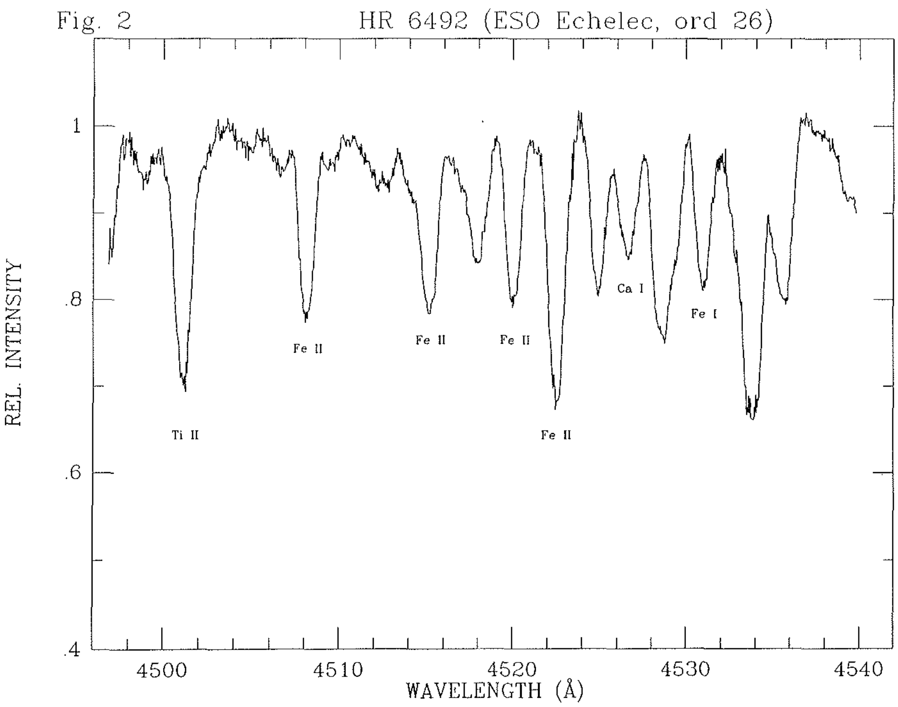


Figure 2: *Portion of the spectrum of star HR 6492 in the spectrum order 26 (4495–4550 Å) observed on September 1988 with the Echelec.*

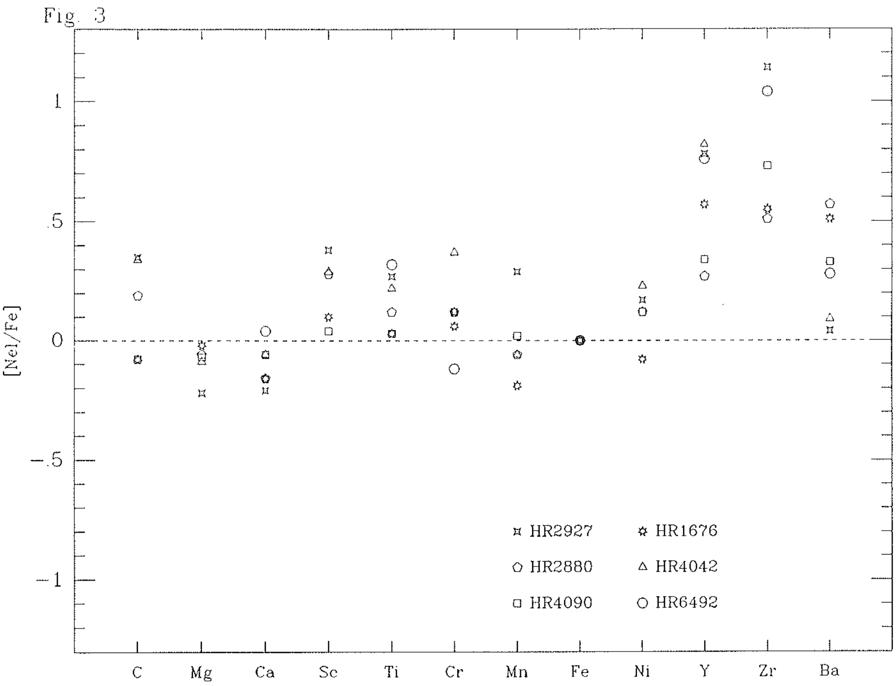


Figure 3: *Logarithmic abundance ratio with respect to the sun normalized to iron.*

high-resolution CCD detector (ESO CCD # 13). The choice of the instrumentation was dictated by the need for observing spectra with a linear dispersion as small as possible and a good S/N ratio (100). In its actual configuration the Echelec allows a linear dispersion of 3.1 Å/mm at 4000 Å to 4.5 Å/mm at 6000 Å. The Echelec resolving power falls between that of the CES (with its short camera R = 60,000) and that of Caspec (R = 20,000), moreover the wide separation of orders permits some binning in the direction perpendicular to the dispersion. This improves the S/N ratio without any loss of resolution. The meteorological conditions were not so good during the observing run and exposure times were 20 to 60 minutes for stars of m_v = 4.3 to 7.4 with a binning of 2 pixels to have at least a S/N ratio ≥ 70 (Fig. 2). 15 stars were measured during these 5 nights in the spectral region 4280–4900 Å. The reduction of these spectra is now being carried out according to MIDAS procedures. The first results we obtained with the new configuration of the Echelec are very encouraging, the quality of spectra will allow detailed abundance analysis. In this paper we present the first results.

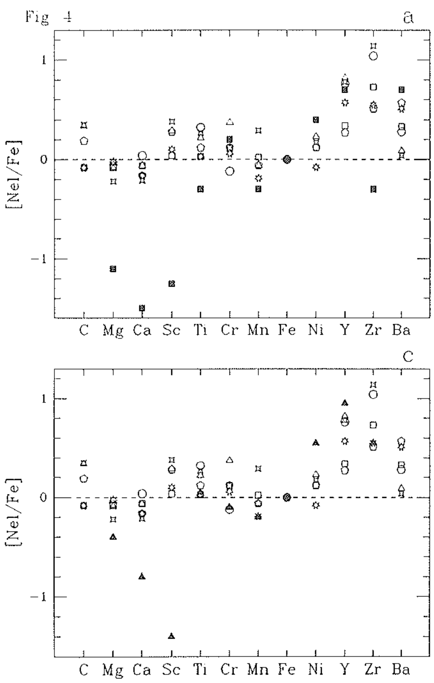
The determination of the atmospheric parameters is presented in detail in a paper to be published in *Astronomy and Astrophysics.* From a temperature distribution with depth ($T(\tau_{5000})$) for a given effective temperature, surface gravity and metallicity, we recompute the ionization equilibrium and hydrostatic equilibrium to determine the total pressure and density at each depth and continuous opacities at selected wavelengths. We then use the model prepared to determine the abundance from the equivalent width by iteration on the solar abundances; this process assumes a homogeneous plane-parallel atmosphere, LTE line formation and Voigt profile for the line absorption coefficient.

4. Results

The results are summarized in Figure 3 which displays the logarithmic abundance ratio with respect to the sun normalized to the Fe abundance. This normalization minimizes the effect of errors in equivalent width scale and in effective temperature and metallic-line star abundances are best represented in this form. An interesting point is to compare these abundances with those of a classical Am star (63 Tau), an evolved Am star (HR 178) and a δ Delphini star (δ Del). This comparison (Fig. 4) points out the fact that the abundance of the stars presented in this paper does not look like that of an evolved Am star or of an Am star. We do not observe the typical underabundance of Ca and Sc of Am stars but on the other hand the configuration of the abundance distribution is close to that of the δ Del star. The δ Delphini stars with a subgiant or giant luminosity are defined as stars having abundance anomalies comparable with those of the main sequence classical Am stars, except for Ca and Sc which are normal or overabundant.

5. Discussion

The comparison of abundances normalized to Fe of a classical Am star, an evolved Am and a δ Delphini star raises the question of knowing if there is a link or an evolutionary sequence between these three types of star. Can we consider the assumption of an evolutionary sequence in the variation of the Am characteristics? Can we suppose that during the main sequence phase Ca and Sc are underabundant and when the star reaches the giant phase the abundance of Ca and Sc increases to become normal or overabundant? Thus an Am star leaving the main sequence, would become first an evolved Am star (Ca and Sc are not so underabundant as



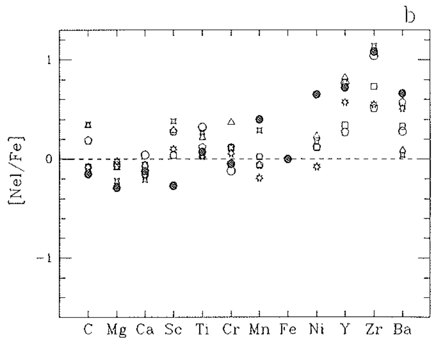


Figure 4a, b, c: *Comparison of 6 A-F giants whose spectra have been taken at Kitt Peak Observatory (KP) and at ESO (★ HR 1676, ◇ HR2880, ☆ HR2927, △ HR4042, □ HR4090, ○ HR6492) with 63 Tau (■) an Am classic star, HR 178 (▲) an evolved Am star and δ Del (●) a δ Delphini star.*

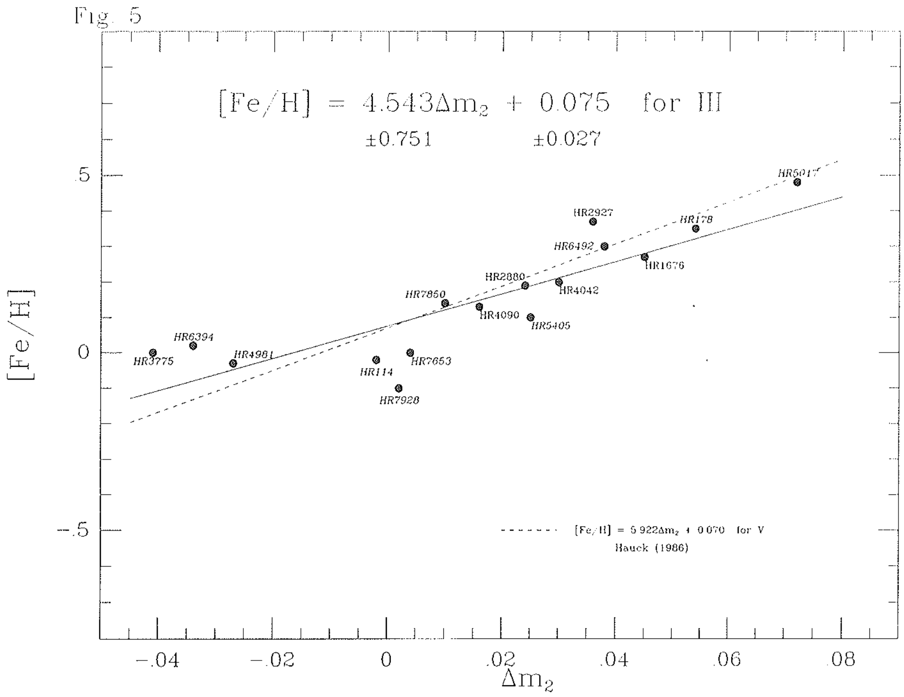


Figure 5: *[Fe/H] vs Δm_2 for A-F giant stars.*

in the main-sequence phase) and then becomes a δ Delphini star, Ca and Sc being normal or overabundant.

Indeed, we observe that the deficiency of Ca and Sc decreases through these three types of star (Am, evolved Am, δ Delphini). But is the disappearance of these Am characteristics really attached to the evolution stage of these kinds of star?

With the help of the evolutionary model (Maeder and Meynet 1988) we plot evolutionary tracks of mass stars 1.5–2.0 $M_\odot$ in the HR diagram. The location of the Am star (63 Tau), the evolved Am star (HR 178) and the δ Delphini star (δ Del) points out the fact that the δ Del star is more evolved than the evolved Am star and that, of course, the evolved Am star is more evolved than the classical Am star. This fact is interesting but the test would be better by using these three kinds of star (Am, evolved Am and δ Delphini) belonging to a cluster, thus the evolutionary state could be determined without ambiguity.

To explain Ca and Sc anomalies, the most useful mechanism is diffusion. The efficiency of this process is strongly dependent on the location of the H-convective zone which is dependent on the temperature, i.e. on the evolutionary stage. Thus observed surface anomalies at a given time mostly depend on the way the diffusion works at this period. The way the abundance stratifications evolve with time depends on the element, and it implies that the star can present different anomalies according to its age.

After these considerations about the possible chemical evolution of the Am stars it is interesting to consider the relation [Fe/H] vs Δm_2 for A-F giants, evolved Am stars and δ Del stars. Stars of Table 1 have been plotted in Figure 5 and it points out a correlation between the spectroscopic value [Fe/H] and the photometric index Δm_2.

The dashed line in Figure 5 shows the relation obtained by Hauck et al. (1985) for the FV stars. The straight line represents the relation, mentioned above, for the A-F giants, the evolved Am and δ Del stars. In the present situation the two relations between Δm_2 and [Fe/H] are relatively close. But a question arises: is

TABLE 1: *A-F Giants, Am evolved and δ Del stars plotted in Figure 5.*

HR	Δm_2	[Fe/H] (Ref)	Sp.T
114	−0.002	−0.02 (2)	Am
178	0.054	0.35 (2)	Am
1676	0.045	0.27 (1)	F2 IV
2880	0.024	0.19 (1)	F0 III
2927	0.036	0.37 (1)	F5 III
3775	−0.041	0.00 (2)	F6 IV
4042	0.030	0.20 (1)	F1 III
4090	0.016	0.13 (1)	F0 V
4981	−0.027	−0.03 (2)	F2 IV
5017	0.072	0.48 (4)	δ Del, F3 III
5405	0.025	0.10 (3)	Am
6394	−0.034	0.02 (2)	F6 III
7653	0.004	0.00 (2)	A4 III, Am
7850	0.010	0.14 (2)	A7 III
7928	0.002	−0.10 (5)	δ Del

References: (1) Berthet (in prep.), (2) Cayrel et al. (1988), (3) Burkhart et al. (1980), (4) Hauck et al. (1985), (5) Lyubimkov et al. (1985).

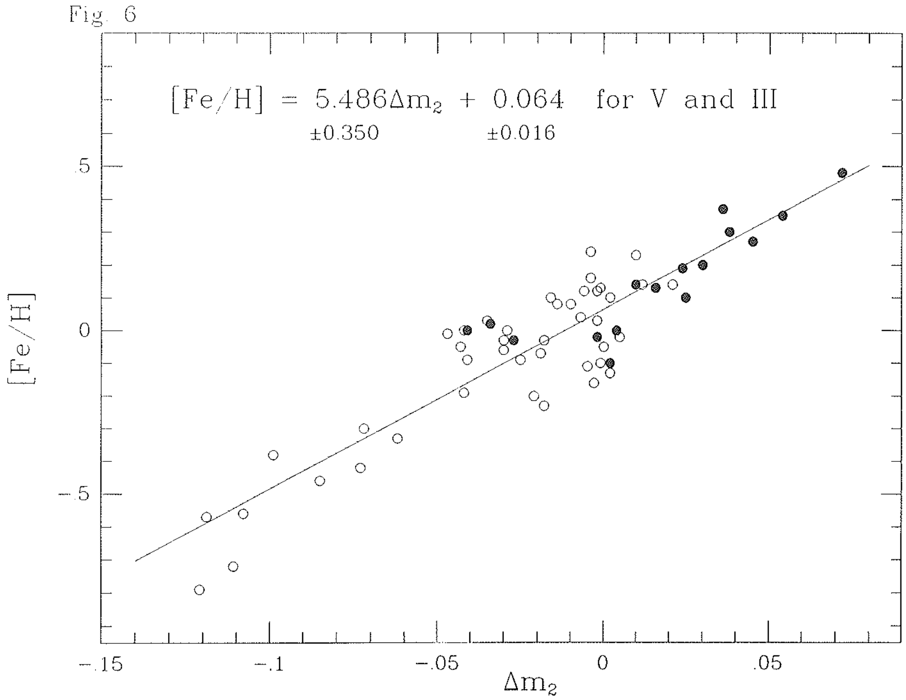


Figure 6: *[Fe/H] vs Δm_2 for A-F giant stars anf F-V stars.*

there one relation for A-F giants and evolved Am stars and another for A-F main-sequence stars? In Figure 6, reproducing our data plus data that Hauck et al. (1985) used to determine his relation, the general trend seems to show that one relation could be sufficient for A-F main-sequence stars, A-F giant stars, evolved Am stars and δ Del stars and this assumption was already suggested by Hauck et al. (1985).

6. Conclusion

The abundance analysis has shown that Ca and Sc abundance of our stars is normal: no deficiency has been found. Thus the answer to one of the introductory questions comes immediately: the A-F giants with a blanketing parameter $\Delta m_2 \geq 0.015$ are not necessarily evolved Am stars, they could also be δ Delphini stars. The relation found between Δm_2 and [Fe/H] is encouraging and supports the possibility of using a photometric parameter to estimate the metal content of these kinds of stars. And perhaps more than that, because it appears that only one relation could be sufficient for the A-F stars. This study points out that it is important to examine the evolutionary stage of the different kinds of stars encountered.

So, with the new configuration of the Echelec spectrograph on the ESO 1.52 m telescope at La Silla we have a very interesting instrument for stellar spectroscopy, working with a wavelength range between 3500 and 5500 Å and a good linear dispersion (3.1 to 4.5 Å/mm). The spectra obtained during our observing run allowed detailed spectroscopic analysis of good quality and encourage us to pursue our programme on the spectroscopic study of A-F giant star atmospheres.

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T Tauri Stars Make Us Wonder What They Are

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Once upon a time, some 4.6 billion years ago, the sun formed in an interstellar cloud of gas and dust. The planets we see in the sky all move close to the ecliptic. It is therefore clear that at some phase the young sun was surrounded by a flat dusty disk, in which these planets agglomerated.

In cosmogony one is concerned about how the solar system came into being. A standing question has been that of universality: do planetary systems form also around other young stars, like the T Tauri stars, which are located in interstellar clouds?

From what we know, these clouds of today are not very different from those present 4.6 Gyr ago with regard to chemical composition and galactic distribution. I would think that ever since the fifties, when the T Tauri stars were recognized as very young objects, most scientists involved have been thinking of the objects as being similar to the sun, only much more active, and that they have circumstellar regions with a flat geometry. There is an early paper by Poveda (1965) with respect to this latter point. Nevertheless, during the late sixties when the infrared excess emission (from circumstellar dust) and the ultraviolet excess emission were discovered, the models always took spherically symmetric forms. One could speculate that it is generally regarded as more scientific (or maybe just simpler) to choose a spherical form when there is no evidence, other than intuition, of a flat geometry. The cosmogonist, of course, always faces a flat geometry.

By 1980 it was evident that for many of these stars the excess emission extends over the far-ultraviolet into the X-ray region. This high-energy tail of circumstellar origin was usually tied to spherically symmetric chromospheres/coronae. During the next years it was also realized that some of these stars drive powerful molecular flows into the surrounding interstellar cloud, often only in two opposite directions (bipolar flows). I left astronomy in 1983. When I came back a few years later I was surprised to see how much is accomplished in science over such a short period of time. The sky had been painted with numerous bipolar flows, some extending over tens of minutes of arc. Plasma jets were seen to shoot out from the stars. A major break-through was the mapping of rotational velocities of the stars and the discovery that some of the light variability present was of periodic nature and related to rotational modulation of bright and dark areas on the stellar surface (see the article in the *Messenger* by Bouvier and Bertout, 1985). It is certainly interesting, also from a cosmogonic point of view, that for many of the youngest T Tauri stars the angular momentum is smaller than the total angular momentum of our solar system! In other words, when the T Tauri stars contract out of interstellar cloudlets, they have found ways to get rid of angular momentum very rapidly indeed. Last, but not least, a number of independent indications that many of the T Tauri stars are surrounded by flat disks of planetary system dimensions had been found. Flat molecular disks, apparently rotating, had been discovered at some stars. The spherical geometry is gone for ever.

The concept of accretion disks, in which material is transported towards the stars, has replaced earlier views. Even the continuous excess emission is now explained as a disk phenomenon. Here, the ultraviolet excess originates in a warm boundary layer between the accretion disk and the star while the infrared excess originates further out in the disk. Some stars lack the characteristics of disks, and on these so-called "naked" T Tauri stars the X-ray variability, for instance, could have its cause in enhanced surface activity. Such activity may exist also on the "clothed" stars but