OUTLOOK FOR ULTRAVIOLET ASTRONOMY

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INTRODUCTION

When Anne asked me whether I would be willing to give this summary and outlook, I was somewhat reluctant because I do not know much about galactic and extragalactic astronomy. Anne replied "Erika, it's all the same physics." This is of course the assumption on which we all base our studies, so I could not object.

When I met Bob Wilson here in March and I mentioned this talk, he said "Oh, that is always nice, because you can put in all your research that you did not have a chance to talk about before."

So I will emphasize the common physics in all or at least most of the IUE studies, and try to give an outlook based on what we have learned so far. I will concentrate on those topics for which I feel I can contribute something to the discussion rather than speculate freely on topics about which I do not know much or to repeat what has been said already in the review talks.

I am sure my forecasts will be generally wrong because the most fascinating research is always stimulated by discoveries that were not predicted.

COMMON PHYSICS OF IUE STUDIES

In our IUE observations we are dealing with wavelengths longward of 1100Å, which means we are using photons corresponding to transitions with energy differences up to 11eV.

Energy differences ΔE enter into astrophysical problems generally by means of a factor $e^{-\Delta E/kT}$ which is most sensitive to changes in ΔE and ΔT for $\Delta E/kT>>1$. This, however, usually leads to small intensities. In most cases the best choice is to observe effects for which $\Delta E/kT$ lies between 1 and 10 which gives good temperature discrimination and still measurable intensities. For $\Delta E \approx 10$eV this leads to temperatures between 10^4 and 10^5K, which is the temperature range with which most of us are dealing.

The solar system observers do not have to worry about intensities and therefore can deal with lower temperatures. Also investigations of interstellar matter may deal with lower T since absorption of hot background radiation is studied.

Most IUE studies deal with gases that are optically thin in the continuum. Since we are dealing with $\Delta E \sim 10kT$ the energy loss of optically thick gases would be too large for the gas to stay hot except if the energy source is directly attached to the gas and increases with increasing temperature as is the case for the stars. For most other objects the available energy is fixed by external sources like stellar radiation, gravitational energies, shockwaves, magnetohydrodynamic effects or possibly cosmic rays. Therefore, generally only optically thin objects can stay hot.

This means nearly all our observations are dealing with non-thermodynamic equilibrium conditions. For the interpretation of the observations we all have to solve statistical equilibrium equations. We should all struggle with the radiative transfer equations. So far mainly stellar astronomers have been brave enough to tackle the full problem. People studying gaseous nebulae in the visual where most lines are optically thin have tried to circumvent the radiative transfer problem by introducing Menzel's cases ABC, thus eliminating the optically thick lines. IUE now leads to the observation of those optically thick lines in the ultraviolet for instance in planetary nebulae or in the bulges of Seyfert galaxies. So now astronomers working on these objects will have to struggle with the radiative transfer problem also.

Every one of us, of course, has a special topic and aim of his or her study, but it seems that the problem of temperature determination, chemical abundance determination, and, above all, the question about the energy sources for the high temperature regions are important in most of the studies. In the following discussion I will, therefore, concentrate on these questions.

After these general remarks let me go into the specific questions. I apologize that I have to be selective and scanty because of time limits.

STELLAR ASTRONOMY

Since I consider myself to be a stellar astronomer I hope you will forgive me if I emphasize this field even though it is by many colleagues considered to be old-fashioned. It is still the backbone of much galactic and extragalactic research.

O AND B STARS

T_{eff} Determinations

For O stars $\Delta E/kT$ reaches values of about 2 for $\lambda \sim 1100$Å as compared to $\sim$0.5 in the visual region. The IUE spectral region therefore offers a much better opportunity to determine effective temperatures for O and B stars (Underhill[1] 1980) though there is still some discussion with respect to the calibration of the T_{eff} scale. With these UV studies we will now be able to distinguish much better between different T_{eff} and correspondingly between different stellar masses and evolutionary time scales than before. This is, of course, quite important for a better understanding of the early chemical evolution of our own and of other galaxies, which therefore in the future will become more transparent.

Stellar Winds

The discovery of strong, highly ionized, high velocity winds in O and BO stars (Morton[2] 1967, Morton et al.[3] 1969) was a big surprise. These winds are still a field of intensive study, especially their source of energy. If during its lifetime on the main sequence a massive star loses about 10% of its mass (Conti[4] 1978) with roughly 3 times the escape velocity (Abbott[5] 1978) we find that the kinetic energy of the lost mass is comparable to the total gravitational energy but to less than 1% of its total luminosity (see also McCray and Snow[6] 1979).

It seems that it is generally agreed upon that the winds are accelerated by radiation (Lucy and Solomon[7] 1970, Castor, Abbott and Klein[8] 1975). Once the high velocities are reached only about 1% of the kinetic energy has to go into turbulence (for a possible mechanism see for instance Nelson and Hearn[9] 1978) and then dissipated into heat to create temperatures around 3.10^5K, which are necessary to ionize OV (Lamers and Snow[10] 1978). Of course Anne Underhill suggested magnetic fields to do the heating and Sreenivasan discussed in London, Ontario, the possibility that differential rotation could cause turbulence and heating. Joe Cassinelli discussed the possibility that X-rays could cause the ionization and actual heating would not be necessary.

From the compilation of Lamers and Snow (1978) we see that at spectral type BO a steep decrease of wind velocity is observed. Joe Cassinelli pointed out that for temperatures less than 30,000K the scattering or absorbing ions may disappear. I would like to suggest that at these temperatures also the photons which can be absorbed or scattered disappear.

In Figure 1 the energy needed per cm^2 for the strong winds, namely 0.1% of the flux or $10^{-3} \cdot \sigma T_{eff}^4$ is plotted as a function of T_{eff}. In the same figure we have also plotted as a function of T_{eff} the flux F_λ per 50Å at different wavelengths according to Kurucz et al.[11] (1974).

Only for radiation shortward of the Lyman continuum edge at 912Å do we see a steep change in the flux for T_{eff} around 30,000K. It therefore appears that the driving force for the wind must be sought for λ<912Å, possibly the HeI lines. Unfortunately this wavelength region is almost impossible to observe, except perhaps with IUE if we think about wavelengths longward of 540Å.

Continuing observations of massive stars with different ages will probably tell us how the winds and mass loss change when the stars evolve off the main sequence, and what will be the final mass of evolved massive stars. This will determine the time scale for the final evolution and therefore the timescale for the expected enrichment of the interstellar medium by heavy elements which determines the chemical evolution of galaxies.

STUDIES OF A STARS

Normal A Stars

Some really old-fashioned astronomers like me still study continuous energy distributions in ordinary main sequence A stars. With $\Delta E/kT$ about 5 to 10 IUE observations offer an excellent opportunity to determine effective temperatures in A and F stars. The observed discontinuity at 1700Å enables us to determine metal abundances as well (Böhm-Vitense[13] 1980a, de Boer, this volume) by comparison with available model energy distributions (Kurucz[12] 1979).

Am and Ap Stars

As we saw earlier, some of the rapidly rotating stars show more energy for λ<1530Å than the slowly rotating stars. I consider this observation important since it may hold the key to understanding the difference between Am stars and normal A stars. It may also hold the key to the understanding of the heating of the outer layers of the O stars if it is due to effects of differential rotation. Future studies will hopefully help to understand the influence of rotation on convection, turbulence, and energy distributions of late A and early F stars.

Monitoring the T_{eff} of the Ap stars during their rotational cycle may tell us about the influence of magnetic forces on the stratification of the outer layers of these stars where magnetic forces could be important.

STARS OF SPECTRAL TYPE F AND LATER

Chromospheric and Transition Layer Emission

The study of classical stellar chromospheres, transition layers and coronae in F,G,K and M stars and the relation to mass loss in late type stars has been an exciting field in the last years. We have confirmed that the boundary line for classical chromospheres follows the Cepheid instability strip, and marks the line where efficient hydrogen convection stops (Böhm-Vitense and Dettman[14] 1980). The exact position within the instability strip is still being studied (Parsons[15] 1980). We expect to learn a lot about the interaction of pulsation and convection from these studies.

We have also learned where on the cool end of the HR diagram the hot transition layer emission terminates (Linsky and Haisch[16] 1979) presumably due to deep reaching stellar winds (Mullan[17] 1978), though we are still looking for an energetic driving mechanism. The influence of Lyα has been discussed by Haisch et al.[18] (1980). X-ray studies of the cool giants and supergiants will show whether these stars actually do not have a transition layer and corona or whether the temperature gradient in the transition layer is too steep to give measurable emission. Vaiana[19] (1980) reports strong X-ray emission of M stars, which may however only refer to very young M stars. The X-ray observations will give us the coronal temperatures and thereby the boundary condition with which we can determine the stratification of the transition layer uniquely. Without it we do not know whether a low-emission line flux of high-excitation lines is due to the absence of high temperature regions, to a steep temperature gradient or to a low electron density.

In any case the complicated structures of the Mg II k_2 emission cores with several shortward shifted absorption components indicate outstreaming material in low temperature high luminosity stars (Stencel et al.[20] 1980). Future studies of late type stars of all luminosity classes will clarify the relation between the termination of the transition layer emission, the presence of the X-rays and the mass outflow visible in the Mg II lines.

The Energy Source for Heating the Transition Layer and Corona

The energy source for the heating of the transition layers and coronae and the energy balance is still a topic of very active research. As pointed out earlier, we feel that the weak or absent transition layer emission of old stars tells us that other than acoustic wave heating must be important for the high layers. Magnetic and magnetohydrodynamic effects will have to be considered. We shall then expect a correlation between rotation and transition layer emission, since magnetic field strengths, due to dynamo generation, are expected to decrease with decreasing rotation. Ayres and Linsky[21] (1980) find a positive correlation between X-ray emission and rotation for G and K stars in binaries. Our studies of the correlation between transition layer emission and rotation shows different results for different spectral types. In Figure 2 we see that the F0 stars η Lep (v_r sin i = 0 km/sec), γ Dor v_r sin i = 106 km/sec) and δ Hor (v_r sin i = 190 km/sec) all show the same weak emission. In order to understand this we must ask why do single stars rotate rapidly? Either they are young and have not had time to slow down in spite of corona and stellar wind, or they have evolved into a region with convection and corona only recently, as seems to be the case for α Tri and 31 Com. In these cases they will have strong transition layer emission. On the other hand, they may also be rapid rotators because they do not have strong convection and therefore do not have a hot corona and stellar wind and therefore have not slowed down as may be the case for F0 stars right at the boundary for the onset of convection like γ Dor, δ Hor and β Cae. With this in mind our Figure 2 does perhaps not contradict a positive correlation between rotation and transition layer emission. Further studies are needed to improve the statistics and decide whether we have a positive correlation or not.

The study of stars with known ages will be very helpful to follow the evolution of chromospheric and transition layer emission with increasing age of the stars. Unfortunately even main sequence F and G stars in clusters are rather faint, except in the Hyades. Perhaps IUE II will help.

Energy Balance and Coronal Temperatures

There has been an extensive discussion in the literature whether the minimum flux corona is indeed the stable form of spherically symmetric coronae as proposed by Hearn[22] 1975.

For any equilibrium stratification we must require that

$$\text{div } F = \text{div } F_{rad} + \text{div } F_{mech} + \text{div } F_{cond} + \text{div } F_{wind} = -\frac{dQ}{dt} = 0 \quad (1)$$

where Q is the enthalpy, F_{rad} = radiative flux, F_{cond} = conductive flux, F_{wind} = energy flux of stellar wind, F_{mech} = sum of energy fluxes which heat the transition layer and corona.

Hearn only considers the $\int \text{div } F\, r^2\, dr$ over the corona.

Let us use the following abbreviations:

$$F_t = \int_{corona} \text{div } F\, r^2\, dr = F_1 + F_m \text{ with} \quad (2)$$

$$F_1 = \int_{corona} (\text{div } F_{rad} + \text{div } F_{cond} + \text{div } F_{wind})\, r^2\, dr \quad (3)$$

$$F_m = \int_{corona} (\text{div } F_{mech})\, r^2\, dr, \quad F_m < 0 \text{ means heat input} \quad (4)$$

$$F_m > 0 \text{ means heat loss}$$

For equilibrium $F_1 = -F_m$.

Hearn showed that for a given n_e the F_1 has a minimum for some $T=T_{min}$. He believes T_{min} to be the temperature of a stable corona.

For stability we must require $\frac{dF_t}{dT} > 0$, then a $\Delta T>0$ will lead to cooling and vice versa. Now $\frac{dF_1}{dT} < 0$ for $T < T_{min}$ as Antiochos and Underwood[23] emphasize. $\frac{dF_t}{dT} > 0$ can then only occur if $\frac{dF_m}{dT} > 0$ for $T<T_{min}$. This shows that the minimum flux corona can be stable only for a positive temperature dependence of the energy input for $T<T_{min}$: For $\Delta T<0$ we need to put in more energy in order to make up for the increased losses in order to achieve some heating. Figure 3 illustrates the situation.

Usually it is assumed that F_m is determined by the conditions in the deeper layers. We therefore expect F_m to be independent of the coronal temperature. In this case T_{min} is not the temperature of a stable corona but rather a lower limit for the coronal temperature.

If on the other hand the coronal heating is due to currents in the corona as suggested by Vaiana and Rossner[24] (1978) then the stability at $T = T_{min}$ will depend on the temperature dependence of such current heating.

In any case the actual temperature must be determined from $F_m = -F_1$. (See also Mangeney and Souffrin[25] 1977).

Following Unsöld's[26] (1955) arguments Hearn's conclusion that the pressure at the base of the corona is determined only by the amount of the mechanical energy input is confirmed in the sense that the energy input into the upper chromosphere determines the pressure at the base of the transition region.

Future detailed studies of chromospheric, transition layer and coronal X-ray emission will enable us to determine the stratification in these layers uniquely and thereby derive div F_{mech} = -div F_1 as a function of height. We will then better understand the details of the heating mechanisms. For a true description of the corona we will have to take into account, though, the none spherical geometry as was emphasized by Vaiana and Rossner[24] (1978).

THE WILSON BAPPU EFFECT

The discovery by Wilson and Bappu[27] (1957) of the increasing width of the Ca II K_2 emission with increasing luminosity has stimulated much research. A similar effect is observed for the Mg II h_2 and k_2 emissions. The surprising fact is that the widths of the lines appears to be independent of T_{eff} and Z. Figure 4 shows a compilation of the available data from Stencel et al.[20] 1980 and from our observations. A very slight decrease is found for lower metal abundances.

This effect has caused a long-lasting debate concerning its origin. Wilson[28] 1972 favored an explanation by an increasing Doppler width. Ayres[29] explains the increasing width by an increasing optical depth in the damping wings of the lines.

For the Mg II lines we can now observe both the h_2 and k_2 lines. For pure optically thin Doppler broadening the two lines should have the same width. For optically thick Doppler broadened lines the k_2 line should be wider by a minute fraction. If the widths are determined by the damping wings the ratio should be about 1.4. The total emission in the lines could also be used in a similar way. Unfortunately on the IUE spectra the measurement of the h_2 line is rather inaccurate since it appears at the ends of the echelle orders. There is a lot of scattering in the measurements but in the average the h_2 line is narrower by a factor 1.4±0.5. It is not quite clear whether the ratio is intensity dependent.

Perhaps it will be possible in the future to get a more reliable calibration even for the low counts at the ends of the echelle orders so that h_2 could be measured more accurately. Then this debate could be settled.

OLD STARS

Chemical Abundances

In our opinion the detection of the radial velocity variations for all Ba II stars (McClure[30] et al. 1980) and the actual observation of the white dwarf companion of ζ Cap (Böhm-Vitense[31] 1980b) is quite important since it opens up the possibility that many abundance anomalies observed in old stars could be due to mass exchange in binaries. McClure et al. pointed out that in relatively open globular clusters like ω Cen might perhaps have binaries. The strong emission lines in the ζ Cap system probably indicate excess hot gas in the system and the strong h_3 and k_3 Mg II absorption lines seem to show excess circumstellar, cool, low-density gas. Future observations of stars with peculiar abundances will help to clarify how many of these peculiarities can be related to white dwarf companions. X-ray observations may decide whether mass exchange is taking place now and in which direction it is going.

X-ray Source in Sirius B

The UV studies of the Sirius system so far have not been able to solve the problem of the X-ray source for Sirius B. Perhaps mass exchange could be an explanation. The question remains, is there gas in the system that could be accreted by the white dwarf? We have looked for signs of it. After the correction of the Sirius B spectrum for the IUE calibration error explained by A. Holm[32] (1979), we still find some humps in the light tail seen perpendicular to the direction of dispersion, which we believe is mainly due to scattered light of Sirius A. Figure 5 shows some of the cross sections through the spectrum at different wavelengths. The points shown are averages over 5 wavelengths. While for the long wavelengths the tail looks smooth with little scatter, we see humps for pixels, 11 or 12 at other wavelengths, some of which are close to carbon lines. The profiles shown were all normalized to FN = 2000 at pixel No. 8 where the Sirius A tail starts. The actual counts in Figures 5b-d are lower by about a factor 2 as compared to Figure 5a. Can we believe the hump at pixels No. 9 and 12 for these wavelengths? Is there emission in the carbon lines around Sirius B? Additional spectra can perhaps answer this question.

Generally the study of mass exchange in close binaries especially in connection with nova or nova-like outbursts have been and probably will continue to be an active field of research. The flux in the ultraviolet emission lines will tell us how much energy is liberated in the exchange process which gives us a handle on the amount of mass transfer.

YOUNG STARS

With the detection of the bright ultraviolet continua in T Tauri stars (Imhoff[33] 1980) we have at least learned that we do not yet understand what is happening during the birth of a star. The bright ultraviolet continuum of Herbig Haro object No. 1 is, however an even more extreme case (Ortolani and D'Odorico[34]). Figure 6 shows a short wavelength region $4^h\!.5$ exposure of Herbig Haro object No. 1 which was taken by Karl-Heinz Böhm and myself with the help of Fred Bruhweiler. This object has a visual magnitude of about 16, with most of the light coming from emission lines. There is also an estimated 2^m extinction around 1500Å.

Ortolani and D'Odorico find that the relative energy distribution corresponds to a blackbody with $T \gtrsim 40{,}000$K.

We suspect that all Herbig Haro objects have strong ultraviolet continua. This is not predicted by the currently favored hypothesis that the emission is due to shock wave excitation.

In HH 24A the visual continuum was found to be strongly polarized (Schmidt and Miller[35] (1979), Strom et al.[36] (1974)). Is the UV continuum of HH objects also strongly polarized? IUE will not be able to tell us. Could the UV continuum be due to Rayleight scattering? If so, why do we never see the original lightsource? The main problem is, however, to get enough intensity unless the light source is imbedded in the Herbig Haro object. In that case the Herbig Haro object would be expected to be a strong infrared source, which it is not.

Further studies will clarify whether all HH objects have strong UV continua, and how the energy distributions differ for different objects. The relation between the UV energy distributions and the emission line intensities may help to clarify the energy sources for these objects and their relation to star births.

THE INTERSTELLAR MEDIUM

THE GALACTIC HALO

While the Copernicus satellite permitted to observe interstellar lines in the IUE wavelength region even at higher resolution than IUE, IUE has increased the distance range of observations considerably. The most exciting observation in this field is in my mind the confirmation of the existence of high-temperature gas in the galactic halo (Savage[37] 1979) which had been suspected a long time ago (Spitzer[38] 1956). Possibly hot halo gas was also seen in the Magellanic Clouds, Savage[37]. Future observations of extragalactic objects in the local group may show whether hot halos are present in all of the systems or how the presence-or absence-is related to other properties of the galaxies.

The most interesting problem is again the energy source for the heating. Is the galactic halo being heated randomly by supernova explosions as already discussed by Spitzer? This could explain the inhomogeneities of the halo gas. Could the high temperature have survived from the collapse of the galaxy? Spitzer estimated that for $T \gtrsim 10^6$ K the cooling times would be long enough. The inhomogeneities would then be explained by the cooling instability of the hot gas.

If current galactic models are correct (Tinsley and Larson[39] (1978)) which require continuous instreaming of material in order to keep the metal abundance Z of the galaxy from increasing, then it seems the inflowing halo gas will have to be heated more or less continuously unless the intergalactic gas is already hot. If so then due to the cooling instability clouds could condense from the hot gas while cooling and could fall into the plane.

If appropriate background objects can be found, the investigation of the distribution of the hot gas within the halo, especially as a function of galactic latitude and distance, will help us to identify the energy source.

SUPERNOVA REMNANTS

The possibility to study distant hot stars has permitted us to observe galactic supernova remnants, thus giving us a chance to actually study their chemical abundances and test directly our hypothesis of heavy element enrichment of the interstellar gas by supernova explosions, which up to now was difficult to observe.

EXTRAGALACTIC RESEARCH

GALAXIES IN THE LOCAL GROUP

Since I am not an expert in extragalactic research I am not sure whether I should say anything about this field. I will be very brief. As Anne said, basically the same kind of studies discussed so far can be and are being done in extragalactic objects of our local group, except that we are limited to the study of the brightest objects. Since we can overlook the whole extragalactic systems, we are better off than for our own galaxy if we want to study, for instance, variations of chemical abundances as a function of position within the system. The distribution of stellar birthplaces and their properties can also be studied better in extragalactic systems since we are not bothered quite that much by interstellar dust. A simulation of the early stages of chemical evolution of our own galaxy may be witnessed now in the LMC. As stated above for the young massive objects UV observations permit much better temperature and thereby mass and age discrimination. The dependence of mass loss on Z can be studied by comparing the winds of the massive stars in the LMC and SMC with those of stars in our own galaxy. The changes in stellar evolution due to different degrees of mass loss can be observed directly.

Interstellar lines of hot, possibly halo gas have been detected in the LMC (Savage[37] 1980). The overall velocity field of this gas can be studied better in the LMC than in our galaxy and may give us information about the global infall or outstreaming of the hot gas.

ACTIVE GALAXIES

Theoretical studies of energetic shockwaves and the expected UV emission spectra as well as studies of the interaction of relativistic particles with interstellar gas and dust will probably bring us closer to the understanding of the phenomena observed in the nuclei of active galaxies like the Seyfert galaxies. This may ultimately lead to an understanding of quasars and their luminosity function and distances.

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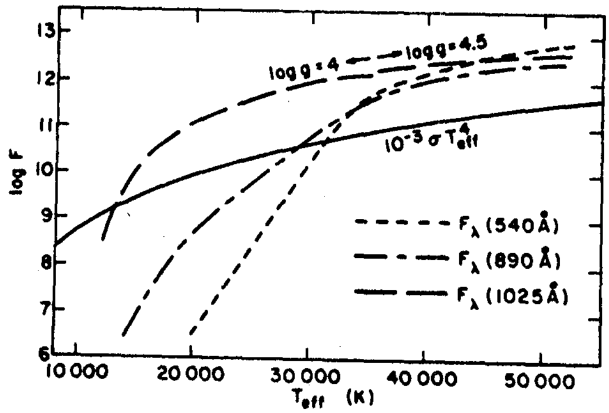

Figure 1: The kinetic energy fed per cm^2 and second into the high velocity wind of 0 stars, i.e. about $10^{-3}\ \sigma\ T_{eff}^4$, is shown as a function of T_{eff}. For comparison we have also plotted for main sequence stars the radiative energy contained in 50Å bands at different wavelengths (according to Kurucz and Peytremann[11] 1972). Only for λ <912Å does this radiative flux decrease rapidly for T_{eff} < 30,000 K. (For T_{eff} > 35,000 K no models with log g = 4. were available, so models with log g = 4.5 were used instead).

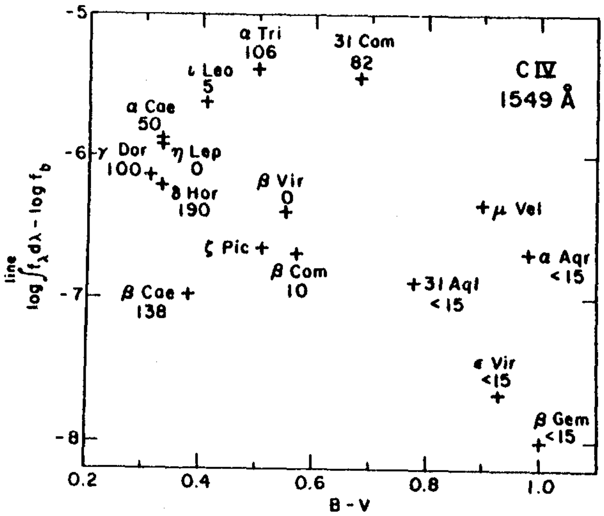

Figure 2: The ratios of the observed emission line flux in the C IV lines at 1549Å to the total flux f_b are plotted as a function of B-V for the stars observed by us. The numbers give the rotational velocities v_r sin i in Km/sec (Boyarchuck and Kopilov[40] 1964). The rather rapidly rotating stars α Tri and 31 Com show more emission than do the slowly rotating stars β Vir, β Com and 31 Aql. However, the rapidly rotating stars γ Dor, δ Hor and β Cae, show less emission than the slowly rotating stars α Cae and η Lep. The latter stars all have B-V<0.40 and are therefore rather close to the boundary line for the onset of convection and chromospheric emission.

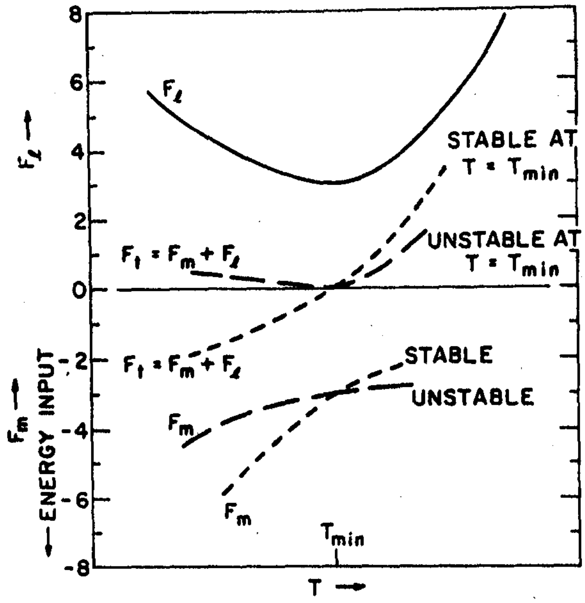

Figure 3: Illustrates the requirements for a stable corona. For a given temperature dependence of the coronal energy losses F_l with a minimum at $T = T_{min}$ the corona may be stable or unstable depending on the temperature-dependence of the energy input $F_l = -F_m$. For a steep increase of F_m with temperature the corona will be stable, possibly even for $T<T_{min}$. For F_m temperature independent or only slightly increasing with T the corona could be unstable even for T>T min.

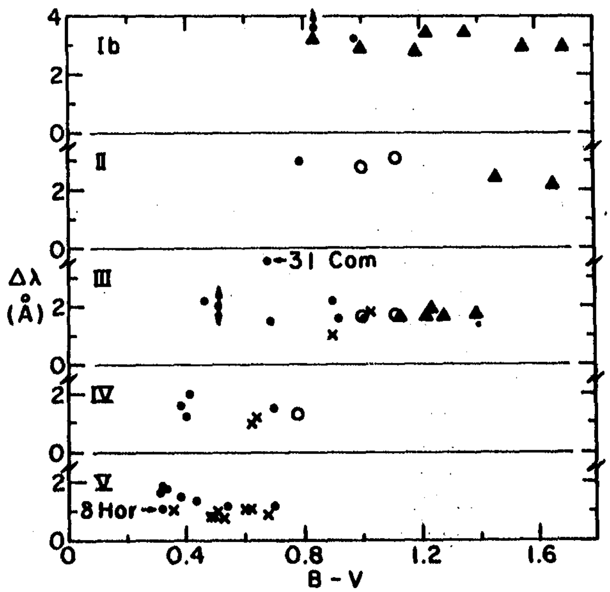

Figure 4: The width at the base of the Mg II k_2 emission lines is plotted as a function of B-V for stars of different luminosity classes. Triangles refer to data given by Stencel et al.[20] 1980. Dots refer to normal metal abundance stars observed by us, x refer to metal deficient stars and open circles to Ba stars or the super metal-rich star 31 Aql. It is obvious that the width is independent of B-V, it decreases slightly with decreasing metal abundance.

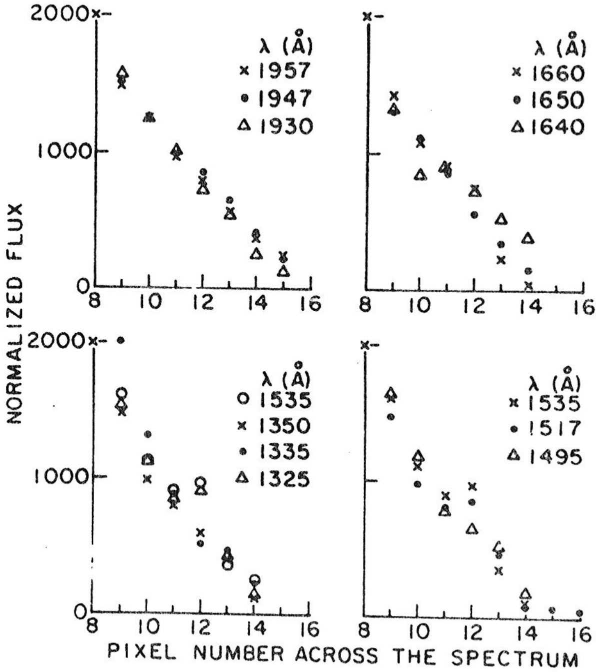

Figure 5: The intensity distribution in the spectrum of Sirius B perpendicular to the direction of dispersion is shown for different wavelengths λ. All cross sections were normalized to the same flux numbers at pixel No. 8. (The intensity maximum is always a pixel No. 6). For wavelengths around 1950Å a smooth distribution is seen attributed to scattered light from Sirius A. At shorter wavelengths humps may occur at pixels No. 9 and 12, shown here for the wavelengths near the CI, CII, and CIV lines. We do not know how to decide whether these humps are just accidental or whether there is a glow in these and other lines in the region around Sirius B.

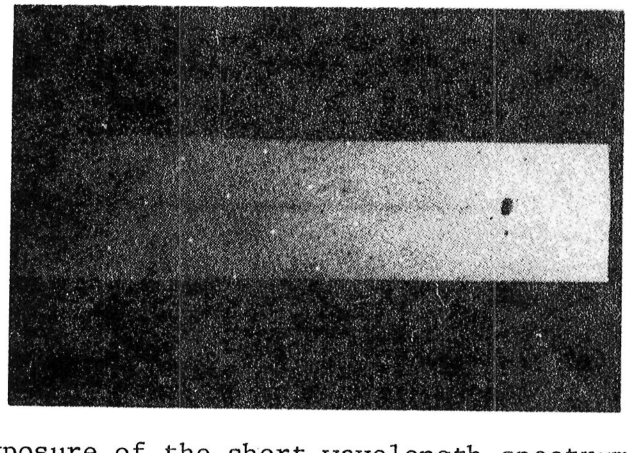

Figure 6: A $4^h\!.5$ exposure of the short wavelength spectrum of Herbig Haro No. 1 ($m_V = 16^m\!.0$). The geocoronal Lyα covers up Lyα of the object. A continuum is visible. In addition weak emission lines of CIII (1909Å), CIV (1549Å), CII (1335Å) and CI (1657Å) can be seen. Faint lines at 1945Å, at 1818Å (SiII), 1751Å (NIII), 1640Å (HeII), 1400Å (SiIV) and 1302Å (OI) may be present.