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THE CONCLUDING REMARKS

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I. INTRODUCTION

We are now finishing the work of this highly successful symposium. And it is the right time to pay tribute to the Organizing Committee for the selection of such an interesting subject for our discussions.

Since the symposium is dedicated to Professor G. Haro, it was desirable to select as a subject one of the fields of his work. But we know that Professor G. Haro has worked with great success in many fields including the problem of blue galaxies, in which he was a true pioneer, the problem of flare stars where he again was an inspiring figure, and others.

However the Organizing Committee was wise in choosing Haro-Herbig objects and T Tauri stars as the main item. Just during the last five or six years we have observed rapid progress in these fields and our ideas about these objects are now based on considerably extended observational material. New important results have been obtained. They are related to

1) The physics and kinematics of HH-objects.
2) The connection between HH-objects and T Tauri stars.
3) The atmospheres of T Tauri stars.
4) The place of these phenomena in the general picture of mass loss and mass outflow at the earliest phases of the formation and evolution of stars.

The Organizing Committee was wise also in putting as the first item of the program the HH-objects and only after that, there started the discussion of T Tauri stars.

This order of items corresponds completely to the most reasonable scientific strategy which begins with the study of more penetrable parts of the problem and continues with less penetrable parts. In our case the HH-objects though containing in themselves a considerable amount of dust are literally transparent for at least some wavelengths, while the central parts of all stars (including T Tauri objects) are completely inaccessible. But of course the information we can have on the external layers of T Tauri stars, on the outflow of diffuse matter and on the integral properties of these stars are of great value.

II. THE EXCITATION OF RADIATION IN HH-OBJECTS

Now there is almost general agreement that the scattering of the light of external sources can play only very modest part as a source of luminosity of HH-objects. In the UV spectrum the scattered light is completely negligible.

As the most probable source of intensive emission lines the shock-wave has been recognized. In the review paper of R.D. Schwartz the reasons for this have been given. There is also an explanation for the intensity of the UV continuum. One considers it as the result of two-photon emission arising from 2s-1s transition of atomic hydrogen.

It is more difficult to explain the ultra-violet *emission lines* belonging to high ions, since the optical part of the spectrum speaks in favor of very low excitation. Therefore, it was proposed that two shocks of different velocity are active here, but at the moment this explanation seems very artificial and further study of the problem is necessary.

It may happen also that high excitation and low excitation emission lines are produced in different parts of the volume of the given objects.

New observations of high sensitivity in the extreme ultraviolet are badly needed.

III. THE KINEMATICS OF HH-OBJECTS

The main conclusion from the extensive work done by Jones and Herbig at the Lick Observatory in the determination of proper motions of HH-objects is that the tangential velocities are large reaching in many cases 300-350 km s^{-1}. After extrapolating the proper motion backward we find there a T Tauri star or an infrared object, from which the HH-object is receding.

It is highly probable that the wind from these young stars is the main source of the excitation of HH-objects.

Now the question is: are the HH-objects simply ejected from the surface of the corresponding stars or they are cloudlets of pre-existing interstellar material which are accelerated by a wind. The theoretical papers on the wind-cloudlet interaction are very important for the solution of this alternative. However, it seems that the hypothesis of ejection from stellar surface is more natural. One must also take notice of the fact that there are as a rule very strong winds from OB stars but we do not observe in their vicinity anything like HH-objects.

According to Jones, there are quite large differences between velocity vectors of different knots within some of HH-objects studied. Gyulbudaghian has noticed that there are indications of divergence of knots and sometimes we can speak even about the expansion of the system of knots. If so the objects will decay in a short time and the conclusion is inevitable that sometime it was a compact object which has desintegrated in its flight away from the exciting star. If so the further study of relative motions of knots are extremely important.

IV. RELATED OBJECTS

Having a spectrum similar to HH-objects the Burnham's nebula is apparently kinematically different from them. Since in many T Tauri stars we do not observe attached nebulae of this type it remains to answer the question about conditions which are favorable for the formation of such nebulae. Apparently some survey of T Tauri stars with the aim to find such nebulae will be very useful.

The optical spectroscopic observations of GGD objects are very desirable. At present it seems that the differences between them and HH-objects are not very great.

V. THE T TAURI STARS

The definition of T Tauri stars has been given by Joy and is based on spectroscopic criteria and on variability. There is no need to change that definition. However, many of us are not very happy with the selection of T Tauri as a prototype and symbol for this class. Perhaps the star RW Aurigae which is much more "active" suits better to this purpose.

Many astronomers consider T Tauri stars as "pre-main sequence stars" imagining that they are moving to the main sequence from above. Professor Haro has several times emphasized that in Orion there exist stars which are certainly below the main sequence. Nevertheless it is apparently true, that T Tauri objects are young stars of masses between 0.1 $M_{\odot}$ and 2 $M_{\odot}$ which have not yet reached the main sequence. We consider it very probable that all stars in this interval of masses pass through this evolutionary phase which being the phase of formation is the first in the life of these stars. This is why we are looking everywhere for post T Tauri (PTT) stars, but not for pre T Tauri objects.

In first approximation the problem of post T Tauri stars has been resolved by Haro, when he has found large numbers of flare stars in clusters and associations. But there remain many questions unanswered. For example, sometimes two phases (T Tauri and of flares) overlap. Does this mean that in stars where we have simultaneously two kinds of activity the T Tauri activity is weaker than in pure T Tauri stars? It is a pity that the question of simultaneous presence of two kinds of activity in the same star has not been discussed at this symposium.

However, in the paper of Mundt and his colleagues the attention was paid to five stars in Taurus - Auriga region with weak T Tauri activity. The problem of their age remains open but it is quite necessary to continue the search of such stars which have spectra intermediate between T Tauri stars, dKe and dMe stars.

The most general conclusion on the broad-band variability of T Tauri stars has been actived in a paper presented by Mendoza. The observations of a considerable number of T Tauri stars during three different epochs show that variations though irregular are taking place in all wavelengths from 1600 A to 22 microns.

The variations are very complicated and this is indicating that it is desirable to introduce some classification of physical variations in order to study them in greater detail. For example, in some papers the authors are speaking about the chromospheric changes and photospheric changes. The problem of different layers (photosphere, chromosphere and corona) has been discussed in a paper presented by Calvet who has also emphasized the importance of the discovery of very hot gas in the atmospheres of T Tauri stars. From this point of view, it is difficult to overestimate the importance of observations made with *IUE*.

Of course, the flares, spots and related phenomena are very important for the variability of T Tauri stars, but at the same time I do not think that for example the bright maxima which in some cases can persist during long times are to be explained by superposition of the large number of flares. But of course flares play a role in all these changes.

VI. THE OUTFLOW OF MATERIAL

As it is known the P Cygni type profiles observed in many of T Tauri type stars speak in favor of continuous ejection of material from the atmospheres of these stars. The mass loss must be of the order of 10^{-8} to 10^{-7} $M_{\odot}$ per year. On the other hand, in some of T Tauri stars the so called anti-P Cygni profiles have been observed. This has been considered by Walker as an evidence indicating the infall of material from outside. Sometimes this phenomenon is considered as a proof of "contraction" of interstellar material.

It seems however, that this assumption of "contraction" or "accretion" of interstellar material must now be completely abandoned since the observations of gas motions around T Tauri stars (in the CO lines) indicate large velocities incompatible with gravitational condensation.

On the other hand, the statistics of velocities of forbidden lines as shown in the paper presented by Appenzeller shows the preponderance of negative radial velocities. And the natural interpretation of this fact apparently must be similar to that given for the preponderance of negative radial velocities among the HH-objects. This means that the dust which is present around the stars absorbs the quanta emitted by the part of the shell which recedes from us.

The observations of profiles of Mg II emission lines (Penston and Lago, *MN*, 202, 77, 1983) are also indicating the outflow of gas in the stars which were observed.

This does not mean that the infall or backfall of the part of the *ejected material* is impossible. In the extremely inhomogeneous conditions in the atmospheres of young stars one part of ejected material can obtain negative radial velocities and return to the photosphere.

All this makes very probable that the winds responsible for the excitation of HH-objects and the outflow of matter from T Tauri stars are similar to each other. But perhaps not always the outflow from T Tauri is sufficient for producing HH phenomena. Perhaps only the more active T Tauri stars can produce these phenomena.

VII. BIPOLAR OUTFLOW

The observations in molecular lines have independently established the existence in molecular clouds of the bipolar outflow from some compact objects. In a number of cases such an outflow is connected with the presence of HH-objects. The natural connection of the two phenomena is obvious. But it remains to explain why the velocity of molecular outflow is usually smaller than the velocity of the HH-objects.

Optically these outflows manifest themselves as cometary nebulae. The heads of the cometary nebulae are considered in such cases as sources of the outflow. But there are indications that in the case of NGC 2261 the real source of the outflow is not the star R Mon but an object, which being situated very near to the source is invisible in optical frequencies. The question arises: What is in this case the role and physical nature of R Mon?

In the paper presented by Levreault, the bipolar outflow associated with the highly variable star PV Cephei was studied. The corresponding cometary nebula GM 29 is also highly variable.

It is quite possible that sources of bipolar outflow discovered until now are not like average T Tauri stars. It may happen that they represent the earliest phases in the life of these stars. Therefore, one of the most important questions, namely, -the nature of the sources of bipolar outflow- deserves further observational work.

During the lifetime of the Galaxy the total number of HH-objects produced should have been very large, perhaps of the order of 10^{12} . This population must form an important component of the interstellar medium which will have much higher dispersion in the Z-axis than other components of the interstellar medium. This can have some consequences for the physics of the interstellar medium. Let us wait for investigations in this direction too.