allowed for since in most cases the stellar images are blurred to the same size due to seeing. Increasing the pixel size has the advantage that the detector's dynamic range is improved. Therefore the square image frame consists of 100 × 100 or 50 × 50 pixels and the image size corresponds to 2.9 × 2.9 $arcmin^2$ at the 1 m telescope.

The First Observations

Due to some technical difficulties with the system's electronics and bad weather conditions in October and November 1981, the instrument could undergo only short test phases at Hoher List Observatory before it was shipped to Chile. During our observing run of 7 nights in January 1982 at the 1 m telescope on La Silla the instrument worked perfectly: for 20 young (blue) and old (red) globular clusters of the LMC surface photometry with 3.45 × 3.45 $arcsec^2$ pixel size could be carried out in the ranges U,B,V,G and R of the UBV and RGU colour systems. (An example of these observations is given in Fig. 3.) The typical integration time per image frame was 3.5 minutes. This shows clearly the enormous effectiveness of such modern panoramic detectors. During the morning hours, when the LMC was too low, we additionally obtained observations of galaxies and some galactic objects (open and globular clusters, Hα regions, planetary nebulae). On 100 × 100 pixel frames (pixel size 1.7 × 1.7 $arcsec^2$) of the globular cluster NGC 3201 stars fainter than $17^m_.1$ and $16^m_.3$ in B and V could be detected (Fig. 4). Up to now only preliminary reductions have been done. However, the enormous amount of data we have collected requires more detailed evaluation to derive brightness and colour profiles of these globular clusters. We hope that we can report about the results in the near future.

Acknowledgement

We thank the ESO technical staff on La Silla for their assistance which contributed significantly to our successful observing run.

Dust and Young Stars in Puppis

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Introduction

Two decades ago the presence of a group of young stars in the constellation Puppis was noted and described by Westerlund (*Mon. Not. R. Astr. Soc.* **127,** 71, 1963). This group appears to form an association of hot and luminous O and B stars also containing the long-period cepheid RS Puppis. The association was named Puppis OB 3. In the region occupied by the association a number of small and peculiar bright nebulae were noted as well as several dark globules and dust lanes (Fig. 1). Also present in the region is the H II region RCW 19 which obviously is excited by the most luminous of the association members. The age of the association was estimated from the most luminous member, the O7f star HD 69464, to be no more than $4 \cdot 10^6$ years. Thus the stage seemed to be set for the scrutinizing of a relatively restricted region of recent star formation concerning the content of both stellar and interstellar material. The following is only intended to be a progress report of this project as some of the recent observational material is still being analysed.

Observations

To get as much information as possible about the different constituents in a region of star formation a number of various techniques must be applied, covering a large part of the electromagnetic spectrum reaching from the ultraviolet to radio. Most of the observational material, in the optical and infrared (IR), for this project was collected at ESO, La Silla, partly together with Westerlund, during the period January 1980 to January 1982. Spectra of the 10 brightest OB stars were taken at high dispersion (12 Å/mm and 20 Å/mm) with the coudé camera of the 1.5 m telescope. These spectra yielded spectral types as well

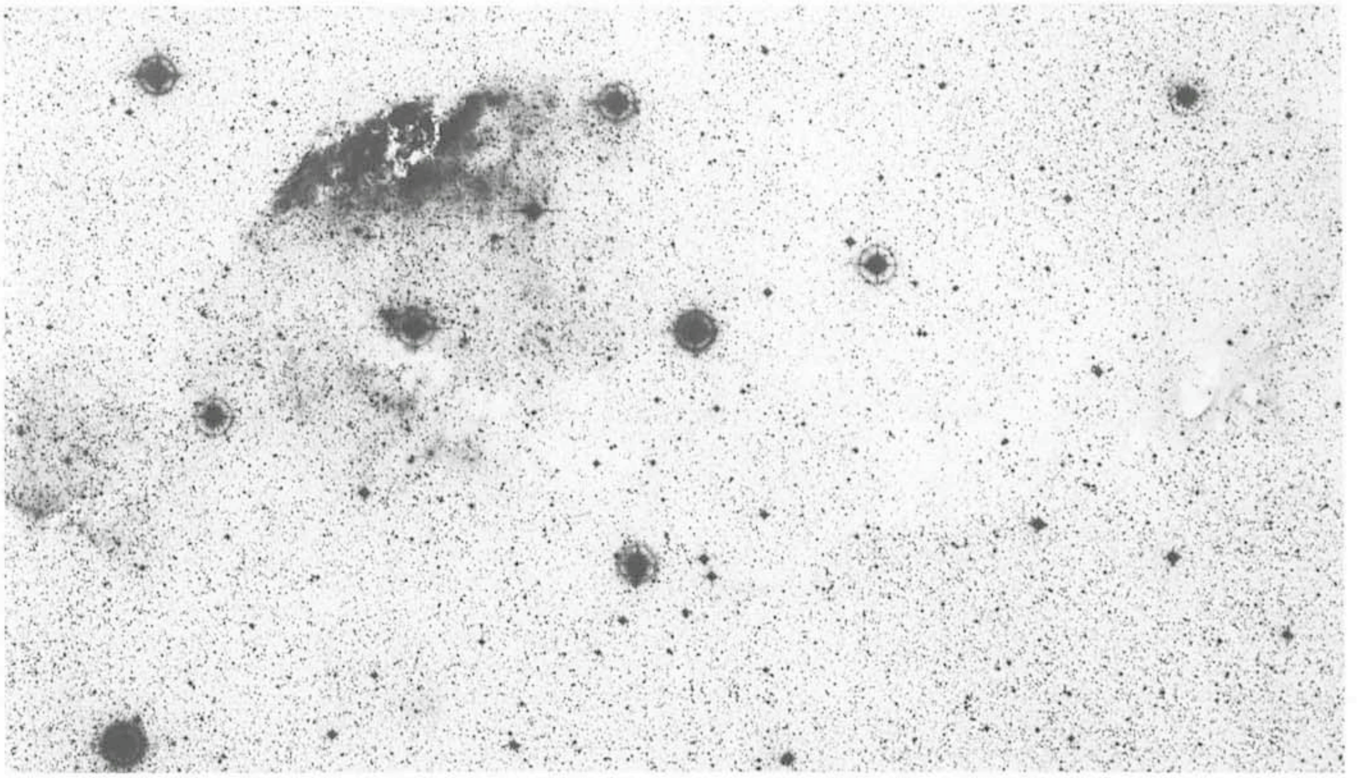

Fig. 1: *The southern part of the region occupied by the OB association Puppis OB 3. This part contains the H II regions RCW 19 (left of centre), excited by the O7f star HD 69464, and RCW 20 (extreme left). To the extreme right is a complex of cometary globules. Projected against RCW 19 and spanning the stellar background between it and the globules is an obscuring dust lane. See also Fig. 5. The bright stars in the field are foreground stars. North is up and east is to the left. (ESO Schmidt telescope red plate.)*

as radial velocities for the stars and for the interstellar K line (Ca II) that was seen towards 8 of the stars. The 1.5 m and 3.6 m telescopes equipped with the Boller & Chivens spectrograph and the Image Dissector Scanner (IDS) were used to get spectra at medium dispersion (114 Å/mm) of the fainter stars connected with the reflection nebulosities as well as most of the bright nebulae in the region.

The 3.6 m and the 1 m telescopes were used with the InSb detector for infrared JHKL(M) photometry both of visible stars and of IR sources found in scanning the areas of the globules and the reflection nebulae in the K band (2.2 microns). A search for Hα-emitting objects has been carried out with the purpose of finding Herbig Ae stars and T Tauri stars, i.e. stars commonly associated with star-forming regions. For this survey a number of objective prism plates were acquired with the ESO 1 m Schmidt telescope. Several promising candidates were found, and IDS spectra of some of them have been secured and UBVRI photometry has been performed with the 1 m telescope.

Further observations of the region have been made in Australia with the radio telescopes at Parkes (6 cm line of formaldehyde) and in Epping outside Sydney (2.6 mm line of carbon monoxide). These observations have yielded information about the molecular gas connected with the obscuring dust in the globules and in the numerous dark patches in the field. Ultraviolet observations of the brightest association members have been acquired with the International Ultraviolet Explorer (IUE) satellite at both high and low resolution. The numerous interstellar lines found in these spectra will provide valuable information on the interstellar medium along the line of sight towards the association.

Some Preliminary Results

From radial velocity data and photometric observations it soon became obvious that the dust and the OB stars were not all in the same volume of space. The large complex of cometary globules to the west of RCW 19 is in fact a foreground configuration as is shown by radio observations of the molecular lines of H_2CO and ^{12}CO. Also geometrical considerations tend to link this complex with the large Gum nebula (cf B. Reipurth, *The Messenger* No. 26, 2, 1981, and T. G. Hawarden and P. W. J. L. Brand, *Mon. Not. R. Astr. Soc.* **175,** 19 P, 1976) at a distance of 450 pc, whereas the H II region with its exciting OB stars seems to fall at a distance of roughly 2 kpc. Whether the dust streak across the field (Figs. 1 and 5) belongs to the globules or the H II region is as yet not quite clear.

Herbig-Haro Object

Let us for a while concentrate on the globules. Radio observations in the 6 cm line of formaldehyde and the 2.6 mm line of carbon monoxide yield a radial velocity of 6 km/sec relative to the Local Standard of Rest. This velocity, combined with the standard circular rotational model for the Galaxy, would place the globules at a distance of 650 pc with considerable uncertainty. In view of this value and their assumed connection with the Gum nebula at 450 pc a distance of 500 pc has been adopted for them. Now let us consider the particular globule in the complex shown in Fig. 2. Immediately apparent is the bright nebula in the middle of the completely opaque globule. An IDS spectrum of this nebula is shown in Fig. 3. It has all the features typical for a Herbig-Haro object, i.e. a nebulosity

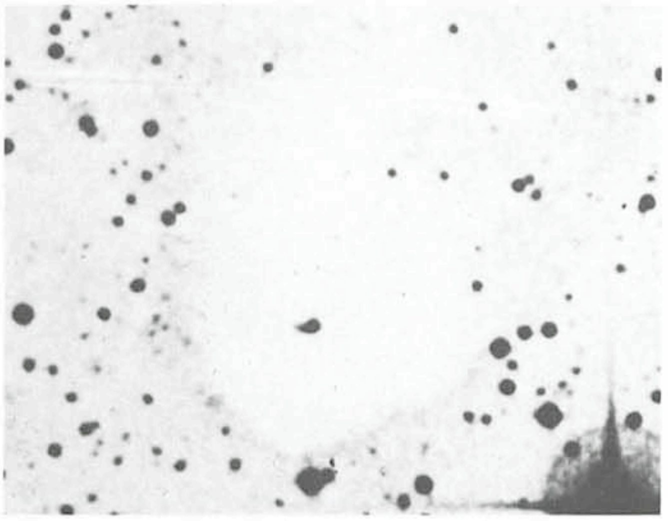

Fig. 2: *One of the globules shown in Fig. 1. The diameter on the sky is 2 arc minutes corresponding to 0.3 pc with an adopted distance of 500 pc. The bright nebula in the centre is a Herbig-Haro object (see text). The linear dimension is approximately 5,000 by 2,500 astronomical units.*

believed to be associated with a star that is still in a state of contraction towards the main-sequence, a protostar. There are several ideas how to interpret Herbig-Haro objects. One school believes that they are reflection nebulae illuminated by scattered light from the protostar, escaping through a hole in the dark cloud, others maintain that they are shock-fronts created as flow of matter from a central protostar (e.g. a strong stellar wind) becomes supersonic at some point of inhomogeneity in the outer part of the cloud. In favour of the shock theory are the spectral similarities between many Herbig-Haro objects and supernova remnants. However, it may very well be that different types of Herbig-Haro objects exist and that both interpretations may be relevant.

The spectrum shown here is typical for what is expected from a shock of a very low degree of excitation. Furthermore, the measured radial velocity relative to the surrounding cloud material indicates an expansion away from the centre of the cloud of 65 km/sec, a velocity that is consistent with theoretical models for shocks in a dark cloud. Thus the conclusion must be that the emission nebula in question is a bona fide Herbig-Haro object consistent with a shock interpretation, and that most likely at least one protostar is hidden in the globule. Scans with the 3.6 m telescope at 2.2 microns have actually revealed three infrared sources in the globule, two coinciding with the Herbig-Haro object and the third situated two thirds of the distance from the centre to the south-eastern rim. The latter is probably a background star shining through. Its infrared colours enable us to make an estimate of the amount of obscuring matter in the globule. If the extinction in the globule follows the normal interstellar extinction law, the total visual absorption at the centre of the globule is at least 35 magnitudes and the corresponding mass 17 solar masses, assuming a gas to dust ratio of 100. This value agrees well with the mass range for Bok globules: 0.1 – 70 solar masses.

Fig. 4 displays two images of the Herbig-Haro object obtained through the courtesy of Dr. H. Pedersen with the Danish 1.5 m and a CCD array. The top image is in the Johnson V-band and the bottom one in the near IR at appr. 9500 Å (Gunn z-band). Note the additional bright spot that appears in the IR image. This spot and the bright knot also visible in the visual image are probably identical to the IR sources found in the K-band. An IDS spectrum

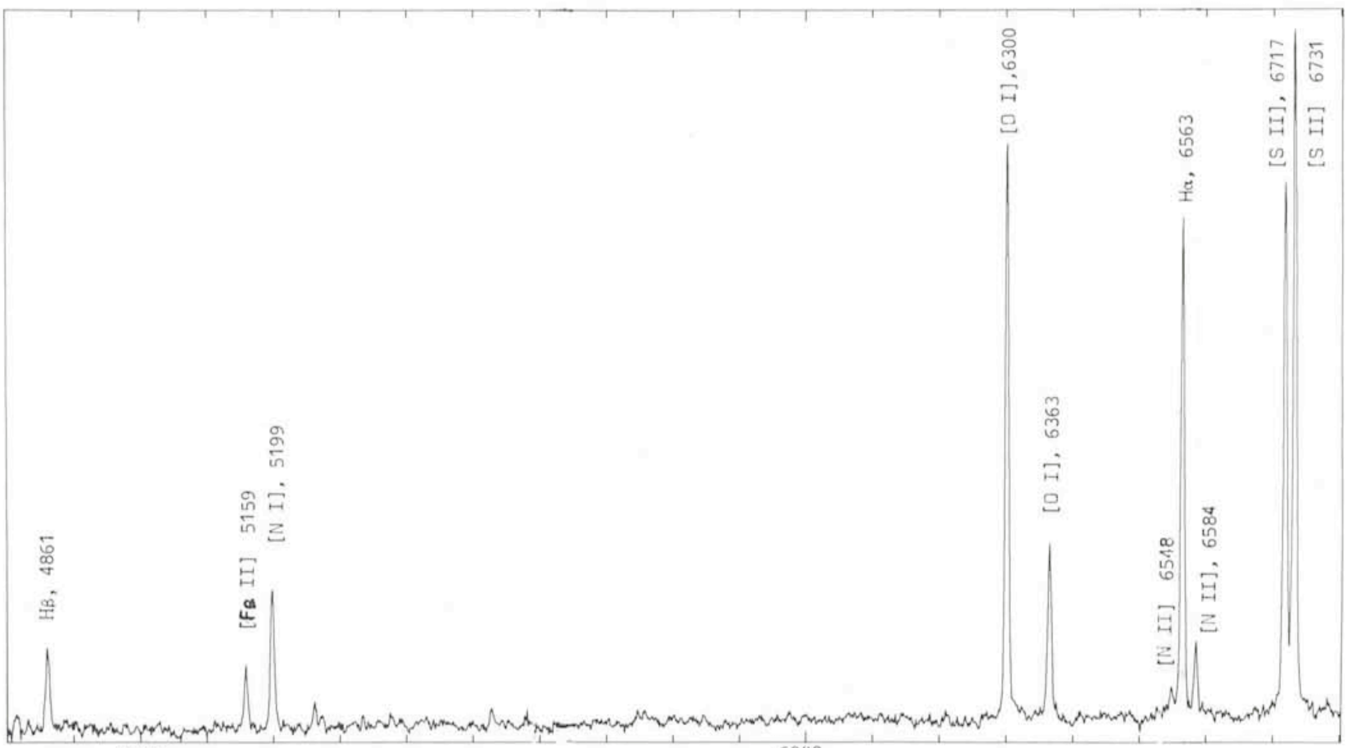

Fig. 3: *An IDS spectrum of the bright condensation in the Herbig-Haro object. The wavelength range is 4800 Å to 6800 Å and the intensity is given in arbitrary units. Note the very strong lines from [O I] and [S II] and the complete absence of [O III] at 4959 Å and 5007 Å. This is indicative of a shocked gas of a very low degree of excitation.*

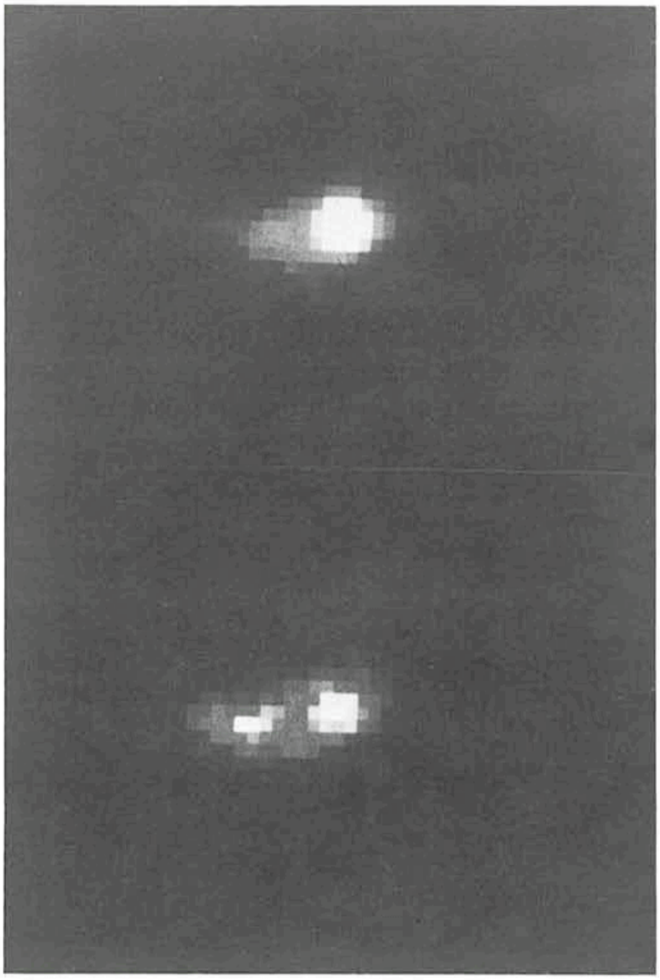

Fig. 4: *Top. A CCD image in the Johnson V-band of the Herbig-Haro object from Fig. 2. It has the typical appearance of a Herbig-Haro object with a bright condensation in an extended nebulosity. Bottom. Same as top but in the near infrared Gunn z-band at 9500 Å. Note the additional bright knot to the left of the "visual" condensation.*

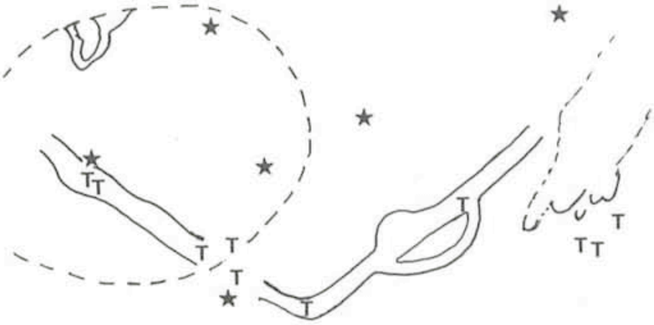

Fig. 5: *A drawing showing the distribution of some of the material in the region. The circular area to the left delineated with a broken line is the H II region RCW 19. The full lines indicate obscuring dust and to the extreme right the complex of globules is sketched in. The locations of the identified T Tauri stars are indicated by 'T'. The positions of some bright foreground stars are given with '*' to facilitate comparison with Fig. 1. North is up and east to the left.*

obtained at the location of the IR spot (Fig. 6) shows a red continuum with possible photospheric features at 5893 Å (sodium D lines) and at 6160 Å (TiO band head). A very tempting thought is of course that we are actually seeing the protostar itself shining through in the IR. However, we may simply be seeing another condensation imbedded deeper in the dusty globule. To settle the matter more observations and a careful analysis are required.

T Tauri Stars

T Tauri stars are a class of low mass stars characterized by erratic light variations and an emission line spectrum of varying complexity from only Ca II and Balmer lines to a very rich emission line spectrum including lines of Fe II and He I. They are generally found close to or imbedded in dust and are considered to be newly born stars with ages less than a million years. If this region of Puppis is to be regarded as a region of star formation, T Tauri stars should be present. The search for Hα-emitting stars resulted in the detection of about 40 emission line objects. So far 10 have been identified as T Tauri stars (see Fig. 5). Three of them form a group just to the south of the globules implying that stars may already have been formed from this complex. The rest of the identified T Tauri stars are all seen projected against the dark dust streak across the region. The bulk of the data for these stars is still in the reduction phase.

To summarize this progress report it appears that we have convincing indications for star formation activity in the region of Puppis OB3 in that we have observed several T Tauri stars connected with the dust here. Furthermore we have observed a Bok globule where it appears that a star is forming or very recently was formed inside it. The investigation continues with the final reductions after which it should be possible to present a more comprehensive picture of this apparently not very massive star forming region.

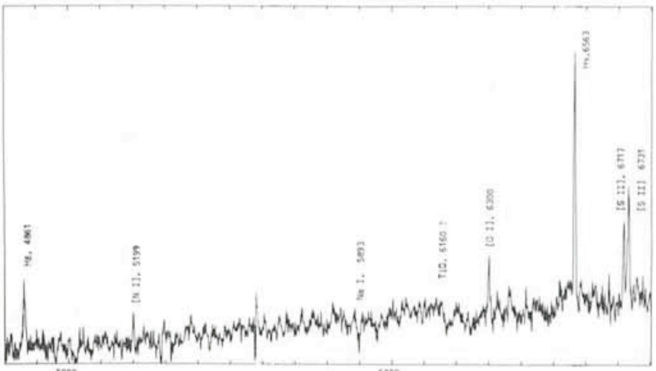

Fig. 6: *An IDS spectrum obtained at the position of the IR knot in the Herbig-Haro object. The wavelength range is 4800 Å to 6800 Å. Note that the intensity scale is increased by a factor 5 relative to that given in Fig. 3. This spectrum has a completely different appearance than that of the visual condensation in that the Balmer lines dominate and that some photospheric absorption features seem to be present.*

Applications for Observing Time at La Silla

Period 31 (April 1 – October 1, 1983)

Please do not forget that your proposals should reach the Section Visiting Astronomers **before October 15, 1982.**