АКАДЕМИЯ НАУК АРМЯНСКОЙ ССР

АСТРОФИЗИКА

ТОМ 11 МАЙ, 1975 ВЫПУСК 2

H$_\alpha$-EMMISSION STARS IN AND NEAR NGC 7000. II.

G. WELIN

Received 25 December 1974

Tentative spectral classifications have been made for most of the hitherto unclassified UH$_\alpha$ stars, by means of objective-prism plates obtained at the Byurakan Astrophysical Observatory. Together with V and B photometry from Uppsala-Kvistaberg plates, the spectral types make it possible to discern between stars associated with the NGC 7000 — IC 5070 complex, and more distant early-type stars. A new H$_\alpha$-emission star (UH$_\alpha$ 142) has also been found.

Introduction. In a previous paper (Welin 1973, hereafter referred to as paper I) a region in Cygnus comprising the North America and Pelican Nebulae (NGC 7000 and IC 5070) was searched for H$_\alpha$-emission stars. This was done as a first step towards identifying objects belonging to the so-called Orion population (T Tauri and T Tauri-like stars etc.). However, almost one half of the H$_\alpha$-emission stars were not assigned spectral classes, due either to their faintness, or to overlapping of spectra on the objective-prism plates used. In order to obtain spectral classifications of further stars in the catalogue of paper I, objective-prism plates were taken with the 1 meter Schmidt telescope of Byurakan Astrophysical Observatory. By using a 1°5 prism, giving reciprocal dispersion of the order of 2000 A*mm*$^{-1}$, together with Kodak IIa-F plates, it was possible to make tentative classifications of stars as faint as about $V = 16$ (depending on colour). Only one star remained unclassified because of its faintness, while the classification of two stars was rendered impossible by overlapping. As was expected, only the H$_\alpha$-emission line was seen from the possible planetary nebula UH. 15, as well as from the stellar object UH. 78 (cf. paper I).

Observational material. The same plate centers were used for the Byurakan plates as for the earlier Uppsala-Kvistaberg plates. On each center three plates were taken, one widened to about 0.1 *mm* (exposure time 15 minutes) and two unwidened (exposure times 14 minutes, and 3 minutes + 30 seconds with a small displacement in right ascension, respectively). In some cases the old Uppsala-Kvistaberg plates were rechecked. Two previously unused Uppsala-Kvistaberg objective-prism plates were also included in the investigation, one Kodak 103a-F + RG1-filter (exposure time 32 minutes), and one Kodak I-N (exposure time 64 minutes, reciprocal dispersion in the near infrared about 1500 Amm^{-1}). Additional photometric measurements have been made on Uppsala-Kvistaberg direct V- and B-plates (exposure time 1 minute, each set of plates taken in direct succession).

Classification of Spectra. All classifications were made by microscope inspection of the plates. Due to the very low dispersion of the Byurakan plates, spectral classifications must necessarily be of a preliminary nature. Absorption lines can be seen with confidence only on the widened plates, and then only when they are very strong. Thus, in general, the over-all appearance of the spectrum is the only classification criterion. However, especially in the case of faint stars, this is often strongly influenced by interstellar reddening. In addition to the notorious difficulty of discriminating between B and F stars, heavily reddened B stars tend to look even as K stars, when their ultraviolet radiation lies below the plate threshold. The short-exposure plates were used for examination of rather bright stars of known spectral types. In this way a calibration for the subsequent classification of remaining stars was established. In the case of stars of intermediary brightness classification was simplified by the use of widened spectra. In some instances the true spectral class might differ considerably from the one given, e. g. due to mistaking faint reddened B stars for late-type stars. Whenever doubt arose about an earlier classification, this was rechecked on the original Uppsala-Kvistaberg plate. Four stars were assigned new spectral types in this way. Some of the M stars could be found on the infrared plate, and were thus classified in more detail.

The newly assigned spectral classifications are found in Table 1, changes from spectral types given in paper I in Table 2. In the case of UH, 117, the change is due to a misidentification in paper I. Magnitudes of the star have been estimated by visual inspection of plates to be about V = 14.5, B = 16.3. A correct identification map of UH, 117 is figure 1. The conclusion to be drawn is that the group of UH, 98, 108, 117, 120, and 125 is merely composed of faint late M-type

stars, and that the emission lines found on McDonald spectra emanate from NGC 7000 itself.

Table 1

NEWLY ASSIGNED SPECTRAL CLASSES OF UH_α STARS. SPECTRAL SUBDIVISIONS WERE DETERMINED FROM AN APPSALA-KVISTABERG I–N PLATE

UH_α	Sp.	UH_α	Sp.	UH_α	Sp.	UH_α	Sp.
1	G	42	F::	85	K	120	M7
2	B:	44	K:	89	K:	121	G:
4	G–K	48	F	93	B	122	G:
6	G:	49	K	95	B::	123	K:
7	F	53	B:	98	M7	125	M7
9	G–K	56	M	100	K:	127	G
10	G–K	64	G:	101	K:	128	F
13	K	66	F:	104	G K	129	B:
14	B	68	K–M	108	M7	131	K:
16	M	69	K:	110	K:	133	B:
22	B	72	M6	111	B::	135	B:
23	K–M	73	G–M	112	C:	136	B:
31	G	81	M8	114	K	139	B
33	M	82	K	118	B:	140	G::
38	K::	84	M	119	B:	141	B

Table 2

SPECTRAL TYPES CHANGED FROM THOSE GIVEN IN PAPER I

UH_α	Sp.	Remarks
74	G:	
83	A0:	
86	A3:	
94	F0–5	Real change, V1057 Cyg.
103	F	Emission at H and K found on Uppsala-Kvistaberg plate
117	M7	See text

On the Uppsala-Kvistaberg 103a-F + RG 1 plate a new H_α-emission star was found. This UH_α 142 is the star BSD 676 (SA 40), according to BSD of spectral type A5, and with medium strength H_α-emission. Estimates of magnitudes are $V = 10.8$, $B = 11.4$. Its position is

$\alpha = 20^h46^m1$, $\delta = +44°37'$ (1950). An identification map is given as Figure 2.

Spatial Distribution of the Stars. With the reasonable assumptions that the distance modulus of the nearer side of the NGC 7000 –IC 5070 complex is about $m - M = 9$, and that interstellar extinction is rather negligible in front of the clouds, backround stars can be identified by means of a colour-magnitude diagram when spectral types are known. In this way all OB stars, most of the B stars, and one A star can be shown to be more distant than the cloud complex. The remainder of the stars are considered as belonging to the clouds, though in a few cases they might actually be foreground objects (or, in the case of misclassification, background stars). Table 3 identifies certain and pro-

Table 3

IDENTIFICATION LIST OF CERTAIN AND PROBABLE (p) BACKHRAUND STARS

UH_1	UH_3	UH_6	UH_7
2	53	91	119
3 (p)	55	93	129
5	57	95	132
14	60	96 (p)	133
18	62	97	134
19 (p)	65	99	135
20	67	102	136
40 (p)	75 (p)	106	137
43 (p)	80	109	138
47 (p)	86	111	139
50 (p)	87	116	141
51	88	118	

bable background stars, while Figure 2 shows their surface distribution with respect to the nebulae and the galactic equator. Figure 3 gives the surface distribution of stars in the clouds, also indicating spectral classes. Many of the B stars believed to belong to the nebulae are heavily reddened, which might be due to circumstellar dust. This is probably also the cause of reddening in some other cases, e. g. UH, 34, a relatively bright G8 star with $B - V \simeq 2$. If this star is situated within the clouds, it would be of luminosity class $\sim$ II, the only later

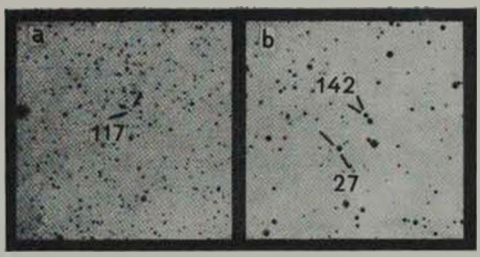

Fig. 1. a) Identification-map of UH$_3$ 117. b) Identification map of UH$_3$ 142. In Fig. 1 north is top, and east is left. Both figures are 16 □′.

To the article of G. Welin

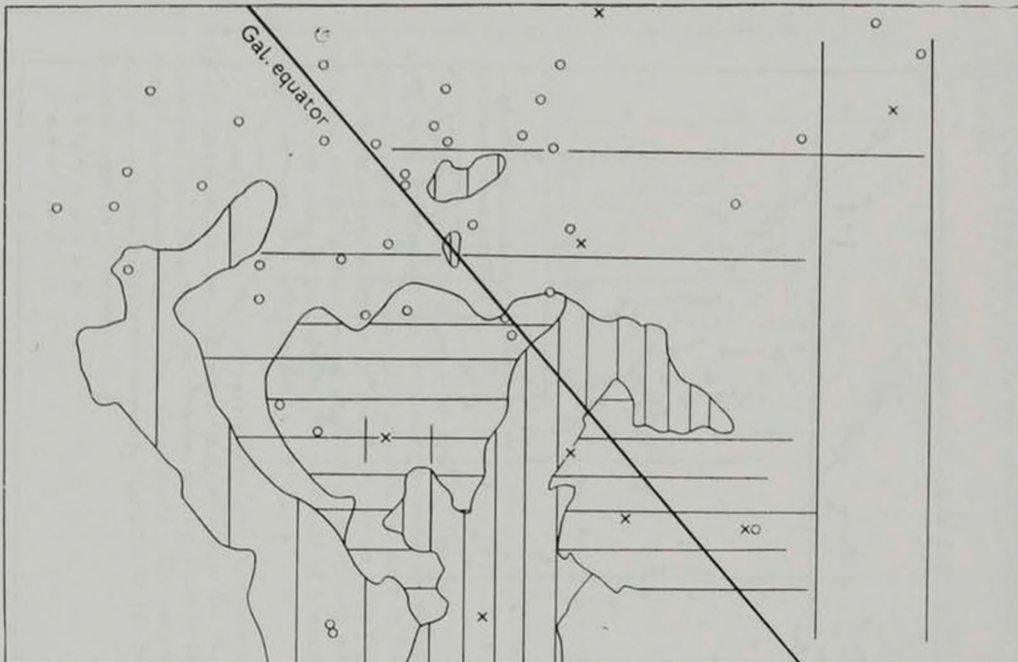

Fig. 2. The distribution of background (o) and probable background (x) stars with respect to nebulosity. Horizontal hatching indicates bright, and vertical hatching indicates dark nebulosity.

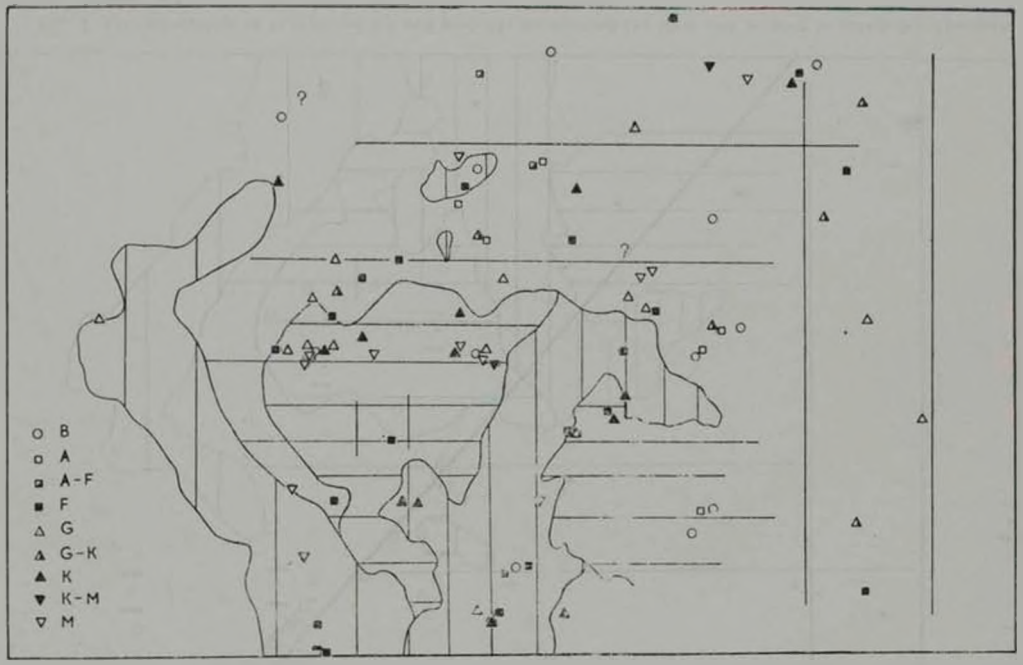

Fig. 3. The distribution of stars belonging to the cloud complex. Hatchings as in Fig. 2.

type H$_\alpha$-emission star there comparable in luminosity with UH, 94 = = V1057 Cygni. This latter star is also probably embedded in circumstellar dust.

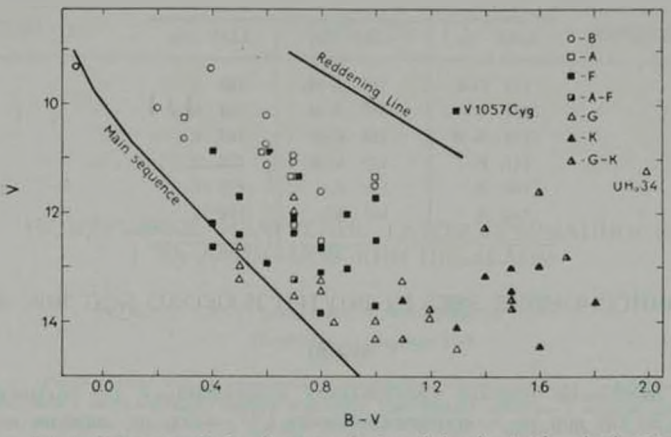

Fig. 4. Colour-magnitude diagram of stars belonging to the cloud complex, with spectral classes indicated.

A colour-magnitude diagram of most of the cloud stars is given in Figure 4. No attempt has been made to make the photometry very accurate, as many, if not most, of the stars are more or less variable, and furthermore the influence of nebulosity varies over the field in a haphazard manner. Rather, mean magnitudes and colours with probable errors of the order of generally one or two tenths of a magnitude were thought sufficient for this purpose.

Acknowlegements. I am very grateful to Prof. V. Ambartsumian and Dr. V. Oskanian for the invitation to Byurakan, to Dr. B. Markarian, who shared his observation time with me, and not least to Mr. V. Lipavetskij, who helped me with the observations. The visit to Byurakan was made possible through the exchange program of the Swedish and Soviet Academies of Sciences.

Appendix

Tentative classifications of some LkH$_\alpha$ stars (Herbig, 1958, Astrophys. J. 128, 259) from a Byurakan plate

LkH$_\alpha$	Sp.	LkH$_\alpha$	Sp.	LkH$_\alpha$	Sp.
132	G-K	151	K-M:	162	K:
137	K	152	K-M:	164	K-M
138	K-M	154	K-M	167	K
141	F:	155	K-M	178	K
144	K:	158	K:	179	G:
146	K	161	K::	184	K

H$_\alpha$-ЭМИССИОННЫЕ ЗВЕЗДЫ ВНУТРИ И ОКОЛО NGC 7000. II.

Г. ВЕЛИН

Выполнена пробная спектральная классификация для большинства до сих пор не классифицированных UH$_\alpha$-звезд, по снимкам, полученным с объективной призмой в Бюраканской астрофизической обсерватории. Спектральные типы, вместе с V и B фотометрией, выполненной по Уппсала-Квистаберг снимкам, позволили различать звезды, ассоциируемые с NGC 7000-IC 5070 комплексом от более далеких звезд ранних типов. Обнаружена также новая H$_\alpha$-эмиссионная звезда (UH$_\alpha$ 142).

REFERENCE

1. *G. Welin*, Astron. Astrophys. Suppl. Ser., 9, 183, 1973.