

A Study of the Open Cluster Tr 14 in the Carina region

Beatriz García³, Stella Malaroda⁴ and Hugo Levato³

Complejo Astronómico El Leoncito. CC 467. 5400 San Juan. Argentina.

e-mail: bgarcia@castec.edu.ar - malaroda@castec.edu.ar

levato@castec.edu.ar

Nidia Morrell^{1,2,3}

Facultad de Ciencias Astronómicas y Geofísicas de la U.N.L.P.

Paseo del Bosque s/n. 1900 La Plata. Argentina.

e-mail: nidia@fcaglp.edu.ar

Resúmen.

Presentamos nuevos datos espectroscópicos para las 9 estrellas más brillantes de Tr 14. Se midieron 80 espectrogramas, tomados en un intervalo de 25 noches, con el objeto de obtener velocidades radiales y establecer la naturaleza binaria de dichas estrellas. Nuestra conclusión es que la mayoría de los objetos estudiados presentan velocidades radiales constantes, mientras que Tr14-20 resulta un sistema SB1, y Tr14-3 un probable sistema SB2 (los números corresponden a Feintein et al. 1973)

Abstract.

We present new spectroscopic data for 9 objects among the brightest stars in the field of Trumpler 14. A total of 80 spectrograms, taken over an interval of 25 nights, were measured in order to provide more information about the binary nature of these objects in the field of Tr 14. From our material, we conclude that most of the stars in the sample show single lines. However, the star Tr14-20 remains as an SB1 system and the star Tr14-3 is a probable SB2 system.

1. The Observations

Table 1 lists fundamental photometric and spectroscopic data for the program stars.

¹Visiting Astronomer, Cerro Tololo Inter-American Observatory. CTIO is operated by AURA, Inc. under contract to the National Science Foundation.

²Visiting Astronomer, Complejo Astronómico El Leoncito. CASLEO is operated under agreement of the Universidad Nacional de La Plata, the Universidad Nacional de Córdoba, the Universidad Nacional de San Juan, and CONICET.

³Member of the Carrera del Investigador Científico del Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina.

⁴Member of the Carrera del Investigador Científico de la Comisión de Investigaciones Científicas de la Provincia de Buenos Aires.

1.1. CCD Spectra

a) Low dispersion spectra.

We have obtained data for stars HD 93129, HD 93128, Tr14-20, Tr14-9, and Tr14-8, using the 2.15 m telescope at CASLEO with a Boller & Chievens spectrograph and a grating of 1200 grooves/mm; such instrumental configuration yields a dispersion of $29 \text{ \AA}/\text{mm}$. We worked in the second order using a BG 18 filter to avoid the first order contamination. We employed an EEV 8605 CCD providing for this configuration a wavelength coverage of 370 \AA , giving a resolution of 1.28 \AA per 2 pixels. The wavelength range was from 3900 \AA to 4700 \AA .

b) High dispersion spectra.

b1) Echelle REOSC at CASLEO.

The stars HD 93129 AB, HD 93128, 3, 4, 8, 9, 20, 21, and 30 in Tr 14 were observed at CASLEO with the 2.15m telescope, and a REOSC echelle spectrograph⁵ with a TEK 1024 x 1024 pixel CCD in the blue region of the spectra. We have used a grating of 400 grooves/mm as a cross disperser. This instrumental configuration gives a 2 pix resolution of 0.30 \AA . For that configuration, the echelle spectrograms cover a useful wavelength range of 2000 \AA (from $\lambda 3000 \text{ \AA}$ to $\lambda 5000 \text{ \AA}$).

b2) Bench-mounted Echelle spectra at CTIO.

NM has obtained some additional spectrograms at CTIO in 1992, using the 1.5m fiber-fed, bench-mounted echelle spectrograph at Cerro Tololo for the stars HD 93129A, HD 93129B, HD 93128, and 20 in Tr 14

The BME has an echelle grating of $31.6 \text{ groove mm}^{-1}$, and a cross disperser of $316 \text{ groove mm}^{-1}$. We used the blue Air Schmidt camera with a Reticon CCD of $1200 \times 400 \text{ pix}$ ($27 \mu/\text{pix}$). A fiber optics of $200 \mu\text{m}$ was used; this fiber projects to a diameter of about $60 \mu\text{m}$ with the Air Schmidt camera. This gives a resolution of about 16000.

1.2. Reduction of the CCD spectra.

The pixel-to-pixel variations were removed by flat field division and the spectra were extracted, normalized and measured using IRAF⁶ routines from version 2.10.

We also obtained spectra for standard stars from Feckel (1988,1991) and for the stars HR 1996 and HR 2806 to establish the zero point correction for our observations, which resulted to be negligible.

⁵On loan from the Institute d'Astrophysique de Liege.

2. Results

2.1. Lines measured

We have measured the radial velocities for the program stars by fitting gaussians, using `splot` routine in IRAF⁶.

We have used the wavelengths from Bolton & Rogers (1978) when available. The rest of the wavelengths are from Moore (1923) except for N V 4603, 4620 that were taken from Striganov & Sventitskii (1968).

In general, we have measured He I, He II, H, N V, N III, and Si IV.

2.2. Analysis of the Results

We have applied a two-way AOV test, as applied among others by Conti et al. (1977), Bohanan & Garmany (1978), Garmany (1980), Gies & Bolton (1986), Levato et al. (1988), to study both plate-to-plate (night-to-night) and line-to-line variability.

The results of this analysis is presented in Table 2, where we show: HD or identification number; mean radial velocity (from the average that results if we include all the lines measured); probable error; number of observations; range of radial velocity; P_{nn} and P_{ll} . The later two quantities are the probabilities (expressed as a percentage) that the observed sample was drawn from a random population (between plates, P_{nn} and lines, P_{ll}). If the probability is lower than 1% for a particular star, we consider that its radial velocity is probably variable. This limit was established empirically. We have indicated our conclusion about the binary nature of each object in the last column of this table: the majority of the member star in Tr14 show a constant radial velocity; the star Tr14-3 is a probable SB2 system, and Tr14-20 is an SB1 system.

Acknowledgments

NM is grateful to Director and Staff of CASLEO for their assistance during the observing run and the reduction of the observations, and thank the Director and Staff of CTIO where she made some of the observations.

On the other hand, we are deeply indebted Dr. Nolan Walborn to permit us to use the echelle spectra taken at CTIO as a part of their own investigation in the region of η Carina nebula.

We appreciate the contribution of G. Bosch and M. Grosso who have taken some spectrograms which we have used in this work, and, finally, we thank Roberto Méndez who gave us their preliminary results of some physical parameters of the stars in this region of the sky.

The authors acknowledge use of the CCD and data acquisition system supported under US National Science Foundation grant AST-90-15827 to R. M. Rich, and to J.-C. Mermilliod for permitting us to use his Data Base on Open Cluster.

The present work was partially supported by the Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina.

⁶IRAF is distributed by the National Optical Observatories which is operated by the Association of Universities for Research in Astronomy, Inc. under cooperative agreement with the National Science Foundation.

References

- Bohanan, B. & Garmany, C. D. 1978, *ApJ*, 223, 908
 Bolton, C. T. & Rogers, G. L. 1978, *ApJ*, 222, 234
 Conti, P. S., Garmany, C., & Hutchings, J. 1977, *ApJ*, 215, 561.
 Feinstein A., Marraco, H. G., & Muzzio, J. C. 1973, *A&A*, 12, 331.
 Fekel, 1985, in "Stellar Velocities" IAU Coll. N° 88, eds. A. G. Davis Philip & D. Latham, p. 335.
 Fekel, 1991, private communication.
 Garmany, C. D., Conty, P. S. & Massey, P. 1980, *ApJ*, 242, 1063
 Gies, D. R. & Bolton, C. T. 1986, *ApJS*, 61, 419
 Levato, H., Malaroda, S., Morrell, N. & Garc'ia, B. 1988, *ApJS*, 68, 319
 Moore, C. T. 1923, *Princeton Univ. Obs. Contrib.*, N° 20
 Striganov, A. R. & Sventistskii, N. S., 1968, *Tables of Spectral Lines of Neutral and Ionized Atoms*

Table 1. Photometric and Spectroscopic data for Stars observed in Tr 14

HD/Id. Num.	V	B-V	ST ¹	ST ²
93129A	6.97	+0.16	O3 If	O3 (f)
93129B		+0.25	O3 V((f))	
93128	8.84	+0.25	O3 V((f))	O4 V
3	10.80	+0.26		B0.5 IV/V
4	11.08	+0.24		B0 V
8	9.40	+0.15	O6.5 V((f))	O7 V
9	9.92	+0.21		O8 V
20	9.61	+0.28		O6 V
21	10.88	+0.34		O9 V
30	10.08	+0.50		B0 III/IV:

1 - Walborn 1973
 2 - Morrell et al. 1988

Table 2. Statistical Analysis in Trumpler 14

HD/Id. Num.	< R.V. > kmsec ⁻¹ (Present work)	p.e. kmsec ⁻¹	n	Range kmsec ⁻¹	P ₉₉ %	P ₁₁ %	Comment
93129AD	-5.0	1.2	19	36.6	~ 25	<< 0.1	Const.
93128	+5.8	0.9	17	22.7	~ 25	< 0.1	Const.
3	-2.7	4.7	4	28.1	-	5 < P < 10	SB2?
4	+14.3	1.6	3	7.6	> 25	~ 0.1	Const.
8	+2.3	1.1	10	15.1	> 25	0.5 < P < 1	Const.
9	+4.5	1.0	7	9.8	10 < P < 25	0.5 < P < 1	Const.
20	+4.6	1.2	11	21.5	< 0.1	2.5 < P < 6	Var.SB1
21	+9.7	2.2	6	15.9	> 25	> 25	Const.
30	+12.1	1.9	2	6.7	> 25	1 < P < 2.5	Const.