Phenomena of hyperionization and emission in the gaseous envelope of the star λ Orionis

Danezis, E., Nikolaidis, D., Lyratzi, E., Theodossiou, E., Stathopoulou, M., Kiriakopoulou, A., Cristou, G. and Drakopoulos, Ch.

University of Athens, Department of Physics,
Section of Astrophysics-Astronomy and Mechanics.

1. Introduction

Schhlesinger and Jenkins (1940) mention λ Orionis as a variable binary system with a spectral type Oe5. The two stars of the system, HR1879 and HR1889 have the same coordinates ($a=5^h\ 29^m\ 38^s$ and $\delta=9^o\ 52'$ for 1950) but with different apparent magnitudes m_1=3.66 and m_2=5.66 respectively. Jeffers et al. (1063) mention λ Orionis as a visually binary system with a primary star as former spectral type and fainter the secondary one. The primary star' s age and mass are $t=8X10^6$ years and 20Mo (Iben 1967). The distance of λ Orionis from the Sun is 430pc and its luminosity is $L=10^5$ Lo (Panagia, 1973). In 1971 Conti and Alschuler classified it as O8IIIe, but finally Walborn (1972) gives the spectral type O8IIIf which means a presence of emiting ionized He (λ4686 A) double ionized NIII (λ 5696 A) and probably emission by ionized CIII (λ 5696 A). In 1974 Lamers et al. studying the intensity of FeII (λ 2548 A) and FeIII (λ 2078 A), as well as the visual region of the star's spectrum, came to the conclusion that λ Orionis is a normal star with an irregular spectrum in UV. They emphasited that the shape and the FeII's spevtral lines is rather weak and the MgII's spectral region may emit. Lindroos (1985) included λ Orionis in a project about visually double star and proposed that it may belong to a triple system. According to the observations by Lindroos, The primary star of the system is a O8III spectral type, the secondary B0V and the third accompanging ia a star with a F8V spectral type. Theodossiou and Danezis studying 500 former type stars including λ Orionis, cocluded that its effective temperature is Teff=35.000±2.300 K.

The atmospherical model

Considering an area of gas consisting of i independent absorbing shells followed by a shell that both absorbs and emits and an outer shell of general absorption, we conclude to the function:

$$I_\lambda = \left[I_{\lambda 0} \exp\left\{-L_{\lambda e}\xi_e\right\} \prod_i \exp\left\{-L_i\xi_i\right\} + \Theta_0\left(1-\exp\left\{-L_{\lambda e}\xi_e\right\}\right)\right] \exp\left\{-L_{\lambda g}\xi_g\right\}$$

where: $\mathbf{I_{\lambda 0}}$: the initial radiation intensity, $\mathbf{L_i}$, $\mathbf{L_{\lambda e}}$, $\mathbf{L_{\lambda g}}$: functions of the rotational and the expansion/contraction velocities (vsini, $v_{ex/c}$),

$\xi = \int_0^s \Omega\rho ds$ where $\mathbf{\Omega}$: an expression of k_λ, $\mathbf{\Theta_0}$: the source function $S_{\lambda e}$, which, at the moment when the spectrum is taken, is constant and

$L = \sqrt{1-\cos^2\theta}$, if $\cos\theta_0 < 1$, or

$L = 0$, if $\cos\theta_0 \geq 1$

where: $\cos\theta_0 = \dfrac{-\lambda_0 + \sqrt{\lambda_0^2 + 4\Delta\lambda^2}}{2\Delta\lambda z_0} < 1$

where: λ_0 is the wavelength of the center of the spectral line and $\lambda_0 = \lambda_{lab} + \Delta\lambda_{\exp}$, where λ_{lab} is the laboratory wavelength of the spectral line and $\Delta\lambda_{exp}$ is the radial Doppler shift and $\dfrac{\Delta\lambda_{\exp}}{\lambda_{lab}} = \dfrac{v_{\exp}}{c}$

$z_0 = \dfrac{v_{\exp}}{c}$, where v_{exp} is the apparent rotational velocity of the i density shell of matter.

$\Delta\lambda = |\lambda_i - \lambda_0|$, where the values of λ_i are taken in the wavelength range we want to reproduce.

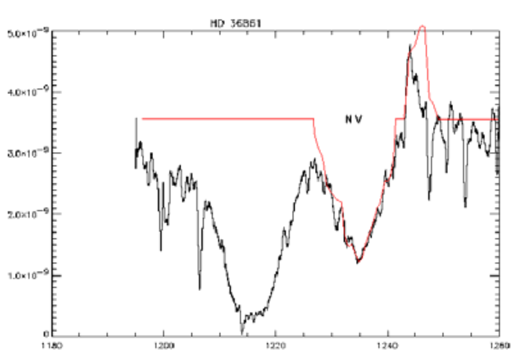
The UV data

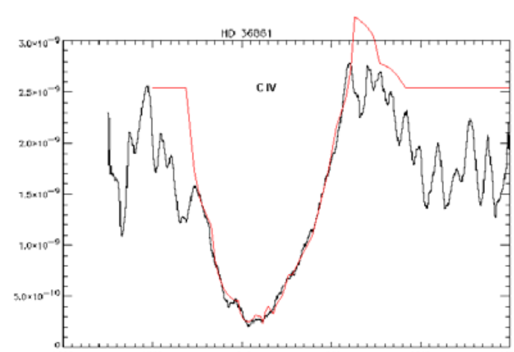
In this project the coronal region's study of star λ Orionis is based on a IUE spectrum taken on 16/4/1981 (SWP 13725) and we study the structure of the spectral lines of: NV λ 1718.55 A, CIV λλ 1548.18 A, 1550.77 A, NIV λλ 1238.821 A, 1242.804 A.

Tables and Figures

The following figures illustrate the spectral lines and the best fit using the model we described. The tables below the figures show the radial velocities of expansion or construction as well as the apparent velocities of rotation of all the observed layers of matter. The diagrams represent the radial velocities of expansion or construction and the apparent velocities of rotation of all the observed layers of matter as a function of atmospherical depth

The model' fit





Each of NV λλ 1238.821A, 1242.804A resonance lines of HD 175754 shows a clear (characteristic) P Cygni profile Which is formed as a composition of 4 independent absorption and one emission components.

Each of CIV λλ 1548.185A, 1550.774 resonance lines of λ Orionis shows a clear (Characteristic) P Cygni profile Which is formed as a composition of 2 independent absorption, and one emission n components.

	V_{a1} (K/s)	V_{a2} (K/s)	V_{a3} (K/s)	V_{a4} (K/s)	V_e (K/s)
NV λ 1238.821 A	-3347	-2596	-1894	-1385	+1036
NV λ 1242.804 A	-3348	-2588	-1884	-1378	+1010

	V_{a1} (K/s)	V_{a2}(K/s)	V_{a3} (K/s)	V_{ga} (K/s)
NIV λ 1718.55 A	-412	-74	+66	0

	V_{a1} (K/s)	V_{a2} (K/s)	V_e (K/s)
CIV 1548.18 A	-1887	-655	+256
CIV 1550.77 A	-1902	-671	+238

	V_{rot1} (K/s)	V_{rot2} (K/s)	V_{rot3} (K/s)	V_{rot3} (K/s)	V_{rote} (K/s)
NV λ 1238.821 A	340	1600	330	340	500
NV λ 1242.804 A	340	1600	340	340	500

	V_{rot1} (K/s)	V_{rot2}(K/s)	V_{rot3} (K/s)	V_{rotga} (K/s)
NIV λ 1718.55 A	700	700	700	100

	V_{rot1} (Km/sec)	V_{rot2} (Km/sec)	V_{rote} (Km/sec)
CIV 1548.18 A	700	700	1150
CIV 1550.77 A	700	700	1150

Conclusions

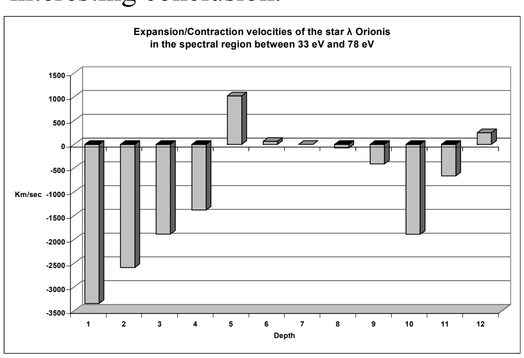
1. The best fit of all lines derived by the model we described lead to the conclusion that the layer of matter in the region we studied (33eV-70eV) is structured as the model describes:

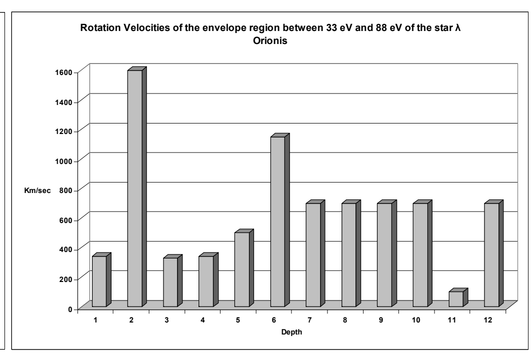
a. An area of gas consisting of I independent absorbing layer of matter.

b. One emitting layer of matter following the absorbing layers.

c. Occasionally, an external general absorption layer of matter.

2. The presence, in the region we study, of succesive shells that expand or contract with velocities between –3350 Km/sec and +1036 Km/sec, while the apparent rotation velocities, in this region, vary between 1600 Km/sec and 100 Km/sec, is a very interesting conclusion.





Acknowledgements

This research project is progressing at the University of Athens, Department of Astrophysics - Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much.

References

Conti, P.S. and Alschuler, W.R. :1971, Ap. J., 170.325c.

Iben, I.:1967, Ann. Rev. Astron. Astrophs., 5, 571.

Jeffers, H. M., van de Box, W, H. and Greeby, F. M.: 1963, "Index Catalogue of Visual Double Star", Publ. Link Obs. 21.

Kelly, R. L. 1987, Atomic and Ionic Spectrum Lines below 2000 A. Hydrogen through Krypton. Part I, II, III. Pshysical and Chemical Reference Data Vol. 16, Suppl. No.1.

Lamers, H. J. G. L. M., Faraggiana, R. and Burger, M.: 1979, Astron. Astrophs., 79, 230-232.

Lindros, K. P.: 1985, Astron. Astrophs. Suppl., 60, 183-211.

Moore, C. E.: 1962, NBS Circ. 488, 1-4.

Panagia, N.: 193, Ap. J., 78. 929.

Theodossiou, E. and Danezis, E.: 1991, Astroph. and Sp. Science, 183, 91-115.

Walborn, N. R.:1972, App. J., 77, 312 w.