*The Be Phenomenon in Early-Type Stars, IAU Colloquium 175*
*ASP Conference Series, Vol. 214, 2000*
*M. A. Smith, H. F. Henrichs, and J. Fabregat, eds.*

# Semi-empirical Model of the Star V923 Aquilae

M. L. Arias[1], L. S. Cidale[2], A. E. Ringuelet[2]

*Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Paseo del Bosque S/N, 1900, La Plata, Argentina.*

## 1. Introduction

V923 Aquilae (HD 183656) is a Be star which shows emission in H$\alpha$, cyclic V/R variations and variations in the near infrared region. This star displays a shell spectrum recognized by Harper(1937) and Bidelman (1950) who both remarked the presence of shell H lines, strong Fe II lines and variable radial velocity. Koubský et al. (1989) proposed V923 Aquilae to be a spectroscopy binary with an orbital period of 214.756 days and a semi-amplitude of 6.2 km/s. Iliev et al. (1994) found a correlation between the changes of the Balmer progression and the asymmetries of the Balmer lines with the orbital phase, considering the period calculated by Koubský.

In our work, we analyze the spectra of V923 Aquilae in the photographic and ultraviolet region for different epochs and estimate the distance from the central star to the line-forming region of Fe II lines as well as the excitation temperature for regions where collisionally dominated Fe II lines are formed. We also obtain values of optical depths and atom columns for these lines. Once these values are obtained, we analyze how they vary with time.

## 2. Methodology

The above mentioned parameters are calculated by means of the method developed by Cidale and Ringuelet (1989) which relates parameters of the observed absorption profiles with local parameters such as excitation temperature, atom column and distance to the line-forming region.

According to Cidale and Ringuelet's model (1989), the absorption depth $r = \frac{F_C - F_L}{F_C}$ of a line formed in an extended envelope is a function of the optical depth $\tau$ and a free parameter $\alpha$, and can be described by:

$$r = (1 - e^{-\tau}) - \alpha[1 - 2E_3(2\tau)] \quad \text{for} \quad \tau < 1 \quad (1)$$
$$r = (1 - e^{-\tau}) + 2\alpha H(\tau) \quad \text{for} \quad \tau > 1 \quad (2)$$

where $\alpha$ is given by:

$$\alpha = \left(\frac{R_e}{R^*}\right)^2 \frac{S_L}{I_\nu^*}$$

[1]Fellow of the CONICET, Argentina

[2]Member of the Carrera del Investigador Científico, CONICET, Argentina



https://doi.org/10.1017/S0252921100056475 Published online by Cambridge University Press

and $S_L$ is the line source function, $R_e$ is the distance of the line-forming region to the central star, $R_*$ is the stellar radius and $I^*_\nu$ is the monochromatic intensity of the star.

For different values of $\alpha$ expressions (1) and (2) yield different curves. The parameter $\alpha$ can be determined from observations, by measuring $r$ directly from the line profile, and it permit us calculate the values of the optical depth $\tau$ and the distance to the line-forming region ($R_e/R_*$) for each line which, in turn, allows us to calculate atom column and electronic temperature of the line-forming region.

## 3. Observations

Our study is based on nine spectrograms, three corresponding to the photographic region and six to the ultraviolet region. The former consist of plates taken at Cerro Tololo Observatory by Ringuelet and Sahade (1981 and 1981), and the latter are images taken from the IUE database. The plates were digitalized using the spectrodensitometer GRANT at La Plata Observatory.

We choose Fe II lines for our analysis, which are abundant in V923 spectra and have narrow deep shell profiles suitable for our measurements. We analyze in particular the multiplets (27), (28), (37), (38), (114) y (144) in the photographic region and UV(1), UV(62), UV(63) and UV(64) in the UV region.

## 4. Results

### 4.1. Photographic region

As regards the photographic region we obtain values of the distance to the line-forming region (in units of stellar radii) that range from 1 to 4.3 approximately. These values can be put into two groups according to the excitation energy of the multiplets. The multiplets with higher excitation energy (114) and (144) ($E_i \approx 4$ eV) are formed in a region closer to the central star than the ones with lower excitation energy (27), (28), (37) and (38) ($E_i \approx 2.8$ eV). According to our model, all the multiplets analyzed have lines that are dominated by the radiation field rather than by collisions, so it was not possible to estimate excitation temperatures in this case.

### 4.2. UV region: LWP and LWR spectra

For the ultraviolet range we find that the selected multiplets: UV(1), UV(62), UV(63) and UV(64) have a source function dominated by collisional processes and that allows us to make an estimation of the electronic temperature which yields $T_e = 10500$ K; this value is consistent with the values found in the literature for circumstellar envelopes of Be stars.

The calculated values of the optical depth are all greater than 1 and the obtained values of $\log(N_i/g_i)$ (where $N_i$ is the atom column and $g_i$ the statistical weight), are similar for all the images with an average value of 13.

The calculated distance of the line-forming region to the central star ($R_e/R_*$), varies for different epochs. Considering the period proposed by Koubský we plotted our values of ($R_e/R_*$) against the orbital phase in Figure 1. There seems to

https://doi.org/10.1017/S0252921100056475 Published online by Cambridge University Press

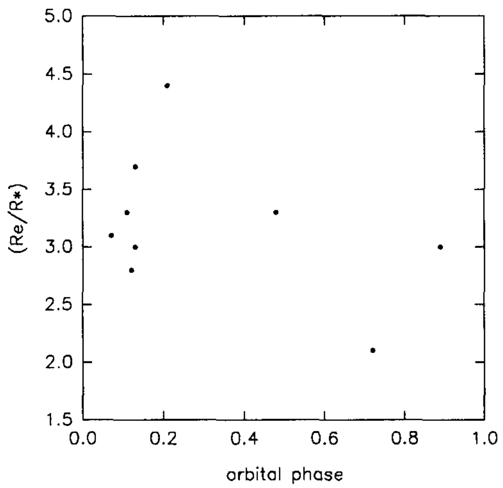


Figure 1. $(R_e/R_*)$ for Fe II lines plotted against orbital phase

be a correlation between $(R_e/R_*)$ and the orbital phase; although it would be desirable to have more available data to make this correlation more definite.

Comparing figure 1 with the radial velocity curve of V923 Aquilae from Koubský et al. (1989) we can notice that the maximum and minimum values of $(R_e/R_*)$ approximately coincide with the values of zero radial velocity. Assuming V923 Aquilae is a binary star, our results could suggest that the envelope of the primary star has its maximum extension in the direction of the secondary while it has the minimum extension in the opposite direction. In other words, we can say that the obtained variation of the distance of the line-forming region reveals us how the secondary star influences the envelope of the primary star. This method might result interesting to analyze other binary systems with observations well dispersed over the period. A more detailed study on the spectra of V923 Aquilae will be published in the near future.

## References

Bidelman, W.P. 1950, PASP 62, 48.

Cidale, L., Ringuelet A.E. 1989, PASP 101, 417.

Harper, W.E. 1937, Pub. Dominion Astrophys. Obs. 7, 1.

Iliev, L. 1994, "Pulsation, rotation and mass loss in early type stars", IAU Symp. 162, p.374.

Jefferies, J.T., "Spectral Line Formation", Ed. Blaisdell Publishing and Company, 1968.

Koubský et al. 1989, Space Sci.Rev. 50, 377.

Koubský et al. 1989, Bull. Astron. Inst. Czechosl. 40, 31-41.

https://doi.org/10.1017/S0252921100056475 Published online by Cambridge University Press