THE WIND SPEED IN THE VELA X-1 SYSTEM

David Salzmann[1,2], Feilu Wang[1,4], Gang Zhao[1], & Lan Zhang[1,3]

We have introduced a new method to analyze spectra from photoionizing plasmas. The method uses a minimum of artificial assumptions, and is based directly on the observed spectrum and well-known rate coefficients only.

The X-ray spectra of the Vela X-1 binary were measured by the Chandra satellite. The spectrum clearly shows the Ly_α and He_α lines of four elements, namely, neon, magnesium, silicon and sulfur, altogether 8 lines. Due to the local wind in this binary system, these lines are Doppler shifted, and from this shift the wind speed was inferred. Our analysis is based on the notion that H- and He-like ions emitting these lines can exist only within well-defined plasma conditions. In photoionizing plasmas these conditions are defined by the ratio $\eta = n_{ph}/n_e$ (n_{ph} is the local photon density and n_e is the electron density) (Salzmann et al. 2011; Wang et al. 2012).

There is a great advantage using η in our analysis, because this parameter depends on the local photon density at r, regardless of where or how the photons were generated and whether or not they were absorbed on their way to r.

In fact, plotting the wind speed, w, as function of η, one finds a consistent, slowly increasing, behavior, see Fig. 1. We combined the results of Fig. 1 with published data (Watanabe et al. 2006). These indicate that the photon density, and thereby η, at every point in the space between the two stellar bodies can be related to the distance from the neutron star. Obviously, η increases monotonously with the intensity of the radiation field. Therefore, it predicts that highly charged ions are produced in the higher intensity part of the field, i.e. closer to the neutron star, whereas the lower charge states are generated closer to the supergiant. It is found that only the Ly_α lines from silicon and sulfur are emitted from the space between the two bodies, whereas the other six lines are emitted from the outer part of the supergiant atmosphere, see Fig.2.

[1]Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China
[2]Weizmann Institute of Science, Rehovot, Israel
[3]CAS South America Center for Astronomy, Camino El Observatorio #1515, Las Condes, Santiago, Chile
[4]wfl@bao.ac.cn

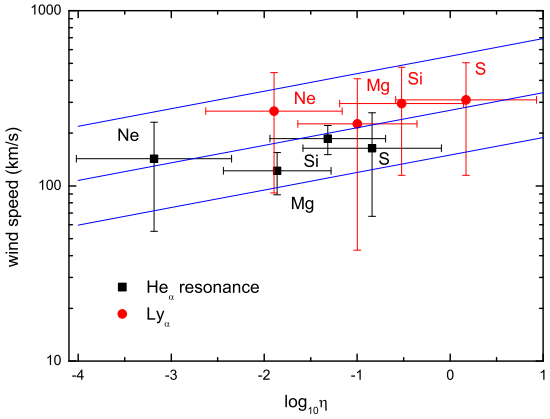

Fig. 1. The wind speed (Watanabe et al. 2006) as function of $\log \eta$ falls within a band having clear boundaries, regardless the plasma material and/or charge state.

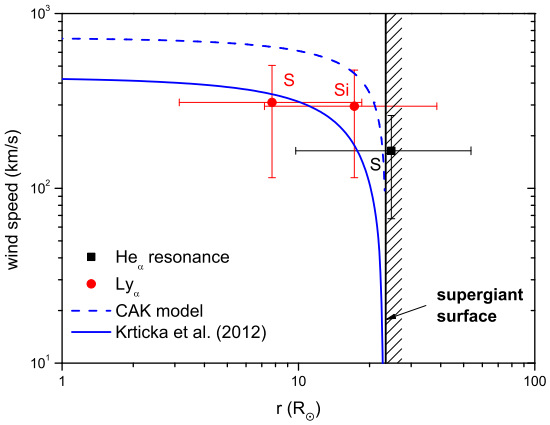

Fig. 2. The wind speed in the Vela X-1 binary system as function of the distance from the neutron star.

Acknowledgements

This work is supported by NSFC under Grant No. 11573040, 11303037, 11390372 and 973 Program under Grant No. 2013CBA01503. L.Z. acknowledges support from CAS-CONICYT Postdoctoral Fellowship administered by CASSACA in Santiago, Chile.

REFERENCES

Salzmann, D., Takabe, H., Wang, F., & Zhao, G. 2011, ApJ, 742, 52
Wang, F., Salzmann, D., Zhao, G., & Takabe, H. 2012, AJ, 144, 122
Watanabe, S., Sako, M., Ishida, M., et al. 2006, ApJ, 651, 421