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LETGS observations of delta Orionis: A collisional ionization equilibrium model

A.J.J. Raassen^{*,†} and A.M.T. Pollock^{**}

^{*}*SRON Netherlands Institute for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands*

[†]*Astronomical Institute "Anton Pannekoek", Science Park 904, 1098 XH Amsterdam, The Netherlands*

^{**}*European Space Agency XMM-Newton Science Operations Centre, European Space Astronomy Centre, Apartado 50727, Villafranca del Castillo, 28080 Madrid, Spain*

Abstract. We present results of the analysis of the X-ray spectrum of the giant O-star δ Orionis (O9.5II), observed in the wavelength range 5–175 Å by the X-ray detector HRC-S in combination with the grating LETG on-board *Chandra*. We report on the Temperatures, Emission measures, variability in the stellar wind, and the distance of the X-ray emitting plasma to the stellar surface.

Keywords: Hot stars; X-rays; spectroscopy

PACS: 32.30.Rj, 97.10.Ex

INTRODUCTION

Since the launch of the first X-ray observatories (*Einstein*, *ROSAT*, *ASCA*) it is known that nearly all O-stars and early B-stars emit X-ray radiation originating in the stellar wind. It is generally believed that instabilities in the strong line driven stellar wind is the mechanism that heats small parts in the wind (e.g., Lucy & White 1980, Dessart & Owocki 2005). The size of these parts (clumps) and the height in the stellar wind where they are formed are still subject of debate.

Recently the X-ray spectrum of ζ Ori obtained with RGS aboard *XMM-Newton* was analyzed by Pollock (2007) and Raassen et al. (2008). Pollock raised the question whether the X-rays were formed further out in the wind and whether cooler plasma would be detectable in the higher wavelength range observable with LETGS aboard *Chandra*. For this purpose δ Ori was observed with LETGS.

RESULTS

The LETGS spectrum of δ Ori did not show line features above 40 Å, but many features of H- and He-like ions and Fe lines below that wavelength.

The line rich spectrum was analyzed with the Collisional Ionization Equilibrium model in *SPEX*. Three temperature components have been determined (see Table 1).

The ratio between the forbidden and intercombination line in the He-like ions is density dependent in cool stars and UV-radiation field strength dependent in hot stars.

TABLE 1. Temperature and emission measures obtained with a CIE model containing 3 components.

	Comp1	Comp2	Comp3
Temperature (KeV)	0.104(.006)	0.210(.008)	0.615(.012)
Emission measure (10^{54}cm^{-3})	1.39(.38)	1.25(.21)	1.25(.26)

The latter is a measure for the distance between the emitting plasma and the stellar surface (Blumenthal et al. 1972). Based on the ions N VI, O VII, Ne IX, and Mg XI (related to going from cooler to hotter plasma) the average emission area is established to be at 50, 7.5, 5, and 2 stellar radii.

FIGURE 1. The f/i ratios in N VI, O VII, Ne IX, and Mg XI as function of the distance to the stellar surface (left panel). Bold the average distance to the surface. The light curve of the X-ray spectrum of δ Ori (right panel).

Apart from this spectral analysis δ Ori is a complex system including an eclipsing companion. At the beginning of the observation δ Ori was eclipsed as is noticeable from the figure of the lightcurve. This indicates that part of the X-ray emitting plasma is nearby the stellar surface, closer than the companion star ($33 R_{\odot}$, $3 R_{*}$).

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