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20Feb06

response to referee's report - MNRAS: MN-06-0094-MJ

Reviewer's Comments:

I found this a very interesting paper to read, with some pleasing results and conclusions. It consists of a detailed analysis of high resolution X-ray data for Zeta Orionis taken with Chandra. This work is important in that Zeta Ori has been used as something of a counter-example to a developing prevailing view of the origin of the X-ray emission in single O stars. This paper demonstrates that, on closer inspection, Zeta Ori is in fact a good example of this viewpoint rather than a counter-example. The paper also highlights some of the outstanding issues with the basic model, and has some broad comments about the possible explanations for them.

The paper is well written, coherent and concise and needs relatively little modification, and as such the paper certainly merits publication.

My comments are detailed below, the vast bulk are minor, involving rewording or action to improve the clarity of the paper or diagrams. The only comment of substance concerns the beta law (see below).

p.1 As a tongue-in-cheek comment, in the first paragraph you cite a record number of papers on O star winds, but manage to miss out a reference to the classic CAK paper. I will leave that to the authors conscience.

Well, the list of citations in the first paragraph (Lucy & White 1980,...) relates to the line-force instability, not the line-driven winds themselves. We have now added a sentence clarifying that this general model exists within the context of CAK winds (and referenced the classic paper). This change induced us also to break off the end of that paragraph - on alternative wind-shock scenarios - into a new paragraph.

p.2 (and elsewhere): "XMM" should be referred to as "XMM-Newton"

OK; fixed.

p.2 "beta velocity law" - this concept is introduced without reference (see also comment below).

OK. We've now referenced Lamers and Cassinelli's textbook. This is such a standard concept now (within the field) that this reference seems appropriate (and indeed, although many concepts in that particular textbook are themselves referenced back to the original research papers, this particular one is introduced in Ch. 2 without reference). It is introduced at the beginning of Ch. 2, with several variations described, and representative values and the corresponding run of v(r) are plotted in Fig. 2.1. on p. 10.

p.2 "overall X-ray properties of Zeta Ori..." provide a reference for this.

We've added Cassinelli and Swank's 1983 paper on Einstein SSS observations of this star and Berghoefer, Schmitt, and Cassinelli's big survey of ROSAT all-sky observations of OB stars to the reference list, and referenced WC2001 as well as these papers where we quote the overall X-ray properties. Note that CS1983 discuss the basic properties (including Lx) and conclude that there is a harder component to the X-ray spectrum (Tx ~ 15 X 10^6 K). WC2001 quote lower temperatures (and indeed the lack of any significant S XV emission in the Chandra spectrum indicates that there isn't much plasma with T>10^7 K); the harder component in the SSS data may very well be due to that instrument's relatively poor spatial resolution (and thus blending with nearby sources). The ROSAT all-sky survey indicates Lx/Lbol slightly higher than 10^{-7} and a quite cool X-ray temperature (about a quarter keV). These references are also invoked in the discussion section.

p.3 The authors refer to Waldron and Cassinelli (2001) as the "discovery paper for Zeta Ori". I would reword or clarify this statement - this paper presented the first high resolution X-ray spectrum for this star.

Absolutely. This has been reworded.

p.3 (and elsewhere) Lyman alpha and Halpha - these should be Lyα rather than Ly$_\alpha$ etc.

OK, fixed.

p.4 (and elsewhere) - a couple of mathematical expressions used within a paragraph are rather small and maybe better off on separate lines (example of s on p.4 and tau on p.6).

OK, we have now typeset these two equations on separate lines. We considered doing the same for a few more equations - including the definition of "x" on p. 3 and some of the ones near the top of p. 5, but decided against it. We will heed the advice of the copy editor, though, if it's deemed we should do the same for more of these equations. Finally, we note that the equation for tau_star is already prominently typeset on its own line when it is introduced (on p. 4), so perhaps this second statement of its definition is unnecessary (we have left it in for now, though, pending further input from the referee, editor, or copy editor).

p.5 Concerning the assumption of a beta=1 wind law. This is the assumption that was adopted in previous work on Zeta Pup (Kramer et al. 2003). Have you investigated how important an assumption this is - does using beta=0.8 (or beta=2) make any substantial difference. My gut feeling is that it is not a major issue (for a plausible range of beta), but would appreciate some comments on this.

This is a good point. We are, unfortunately, constrained by some practical issues. The optical depth integral requires numerical solutions for non-integer beta values - see Owocki and Cohen (2001). In that paper, we compare some beta=1 models to (rather extreme) beta=3 models - see Fig. 2. The qualitative differences in the profiles are not huge, even in those cases. If you look at Fig. 2.1 in Lamers and Cassinelli's book (see above), the beta=0.8 - which is the standard assumption/fit for O star winds - differs very little, in terms of simply the velocity profile, from the beta=1 case we assume here. The slightly more rapid acceleration of the beta=0.8 model would likely move Rmin inward, but just a very small bit (given the ~10% difference in the velocity in the two models near 1.5 Rstar) - and certainly less than the error on the derived model parameters.

In any case, the actual velocity law of the x-ray emitting plasma is not known (independently) and very well may be somewhat different from that of the bulk wind (although not likely too different - see the hydro simulation snapshots we reference elsewhere in the paper).

Perhaps we should add a note (a footnote?) to sec. 4, explaining why we use beta=1. We have not done this at this point, but would be open to doing so if the editor or referee recommended it.

p.10 Table 3 - I would be inclined to bolster the caption for this table, defining a bit more what the columns are.

Good idea. We have added some explanatory text in a new note at the bottom of the table.

p.10 Table 4 - to be picky, you are not consistent in use of the zero in the errors.

OK, I think we've corrected this now by removing the leading zeros in three instances. We chose to exclude leading zeros in this table but keep them in Table 3 because of the small and crowded typesetting necessitated by having different upper and lower uncertainties for most of the values in Table 4.

p. 9-11 Quite a few of the diagrams are too small on the version I received, with the labels almost illegible. They should be larger (or redrawn). Also you do not specify the units of Rmin in the caption or the label of Fig. 6.

We agree, and have now made most of the figures span two columns. We feel that the issue wasn't that the labels were inherently too small, but rather that the figures themselves were too small. In most cases, this is best remedied by having the figures span an entire page. If the copy editor (or the referee!) feels differently, we will remake figures on a case-by-case basis.

Regarding the second point, we've now indicated the units (in the y-axis label) of the R_min plot in Fig. 6.

Other changes:

- Removed one of the Feldmeier et al. references from the third paragraph of sec. 5

- Corrected one of the grant numbers in the acknowledgments section.

- Added a new reference in the discussion section (Cooper et al. 2004) which provides yet more evidence for mass-loss rate overestimates.

- We've broken up the penultimate paragraph of sec. 5, and added a very brief discussion (last two sentences of what is now the third-from-last paragraph of that section) of the trend seen in x-ray temperature (using the shock velocity statistics as a proxy) in numerical simulations of the line-force instability.