Clumping in Hot Star Winds
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Modelling the polarimetric variability of hot stars

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Many hot stars exhibit stochastic polarimetric variability, thought to arise from clumping low in the wind. Here we investigate the wind properties required to reproduce this variability using analytic models, with particular emphasis on Luminous Blue Variables. We find that the winds must be highly structured, consisting of a large number of optically-thin clumps; while we find that the overall level of polarization should scale with mass-loss rate – consistent with observations of LBVs. The models also predict variability on very short timescales, which is supported by the results of a recent polarimetric monitoring campaign.

Introduction & description of the model

Hot stars have long been known to exhibit polarimetric variability. In a recent study, we showed that in the case of Luminous Blue Variables the magnitude of the intrinsic polarization can reach up to 1% (Davies et al. 2005). The stochastic nature of this variability seems to rule-out the presence of a disk / interacting-wind binary as the cause, and instead seems to be caused by wind-clumping. To investigate the conditions required to reproduce this variability, we have constructed an analytic model.

In our model clumps are given a constant angular size, thickness, initial electron density, and ejection rate per wind-flow-time. The clumps are ejected from random positions on the star's surface and move radially outward through the wind according to a β-type velocity law. The total polarization at each time-step is then found from the vector sum of each clump's polarization. We first allow the model to reach steady-state (when the first clumps reach $10\ R_\star$), and then run for 50 flow-times, after which the time-averaged polarization, $\langle P\rangle$, is determined. Here, we summarize the results and predictions, which are published in Davies et al. (2007).

Results & implications

Briefly, we find that the observed level of $\langle P\rangle$ is reproduced in two regimes: optically-thick clumps, with ejection-rates of a few per year; and optically-thin clumps, with hundreds of clumps produced per day (see also Vink et al., these proceedings). The previously-observed shorter timescale variability precludes the dense clumps / few ejections-per-year regime, *therefore we conclude that the polarimetric variability is caused by thousands of optically-thin clumps in a slightly-fragmented wind.*

In this regime, the model predicts that the residual level of polarization should scale with mass-loss rate – consistent with the findings of Davies et al. (2005) that P is generally higher for stars with strong Hα emission. In addition, we expect variability on very short timescales (<1 day) due to the high ejection-rate. This is supported by recent polarimetric monitoring observations (Fig. 1), where we found the magnitude and timescale of AG Car's variablity to be similar to that predicted by a simulation using AG Car-like parameters and an ejection-rate of 200/day (Davies et al., *in prep*). We also find the polarization to be wavelength independent – consistent with electron scattering.

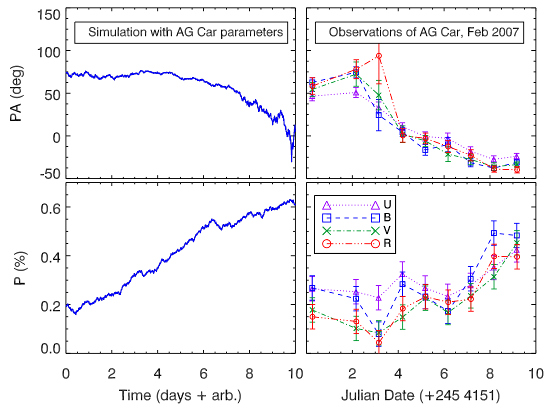

Figure 1: *Left*: snapshot of a simulation using stellar parameters appropriate for AG Car. *Right*: the observed intrinsic polarimetric variability of AG Car. The two have similar variability timescales and magnitudes.

References

Davies, B., Oudmaijer, R.D., & Vink, J.S. 2005, A&A, 439, 1107
Davies B., Vink J.S., Oudmaijer R.D., 2007, A&A, 469, 1045