Modelling Spots in Young, Variable Stars

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Context & Aims

Starspots are a distinct form of stellar activity and occur in the photospheric layer. Hot spots are caused by accreting material impacting the stellar surface. Cool spots are caused by the twisting of internal magnetic dynamo.

Young, developing stars often exhibit both interesting and erratic behaviour in the form of outbursts (the accretion of stellar material) and starspots (regions of the star are hotter or colder). Understanding these natural events is vital to furthering our understanding of stellar evolution and planetary development.

The aim of my research was to reconstruct the observations of some interesting Young Stellar Objects (YSOs) by creating a model using synthetic data.

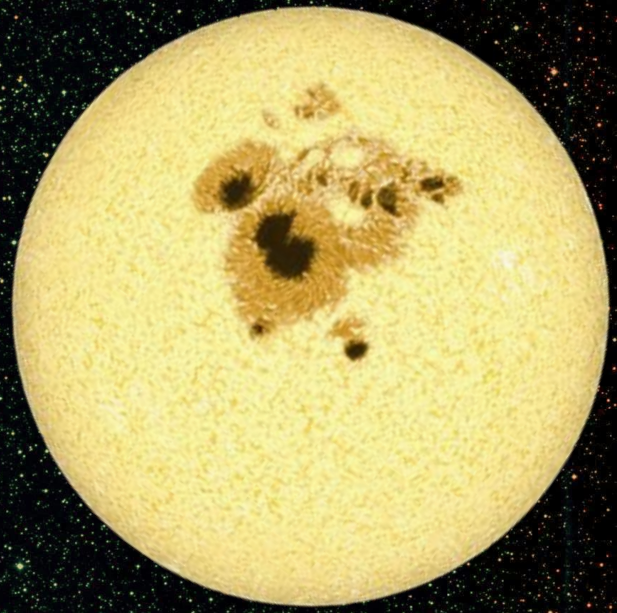
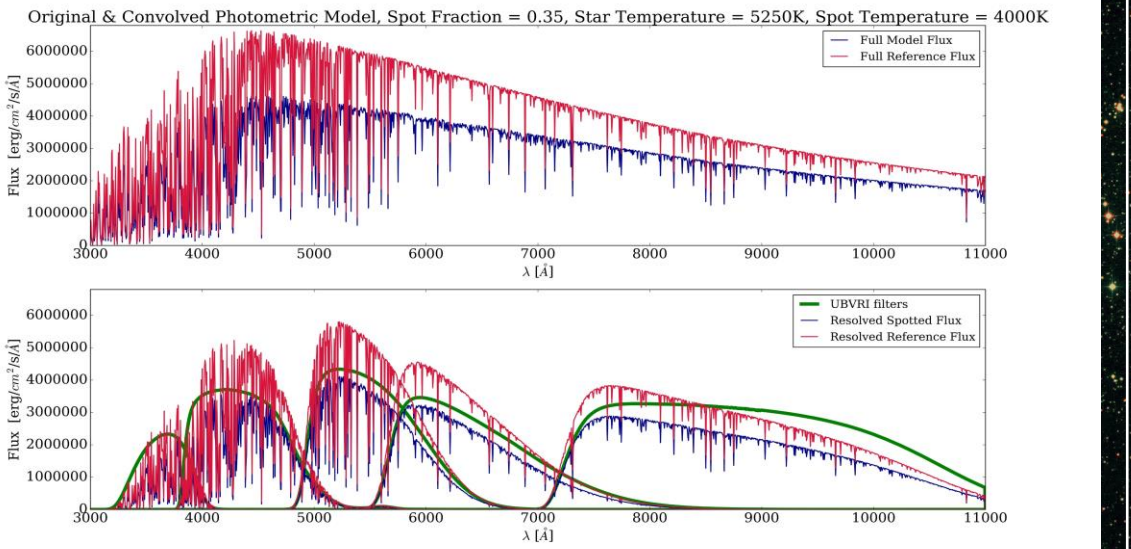


Illustration of starspots in the photospheric layer [1].



The figure shows the photometric starspot model of wavelength against flux. The red data is the flux of the star at a constant temperature of 5,250 K. The blue data is the flux of a star with a temperature of 5,250 K, with cool spot coverage of 4,000 K at 35%. The green lines show the model convolved with some standard filters used in astronomy.

Methodology

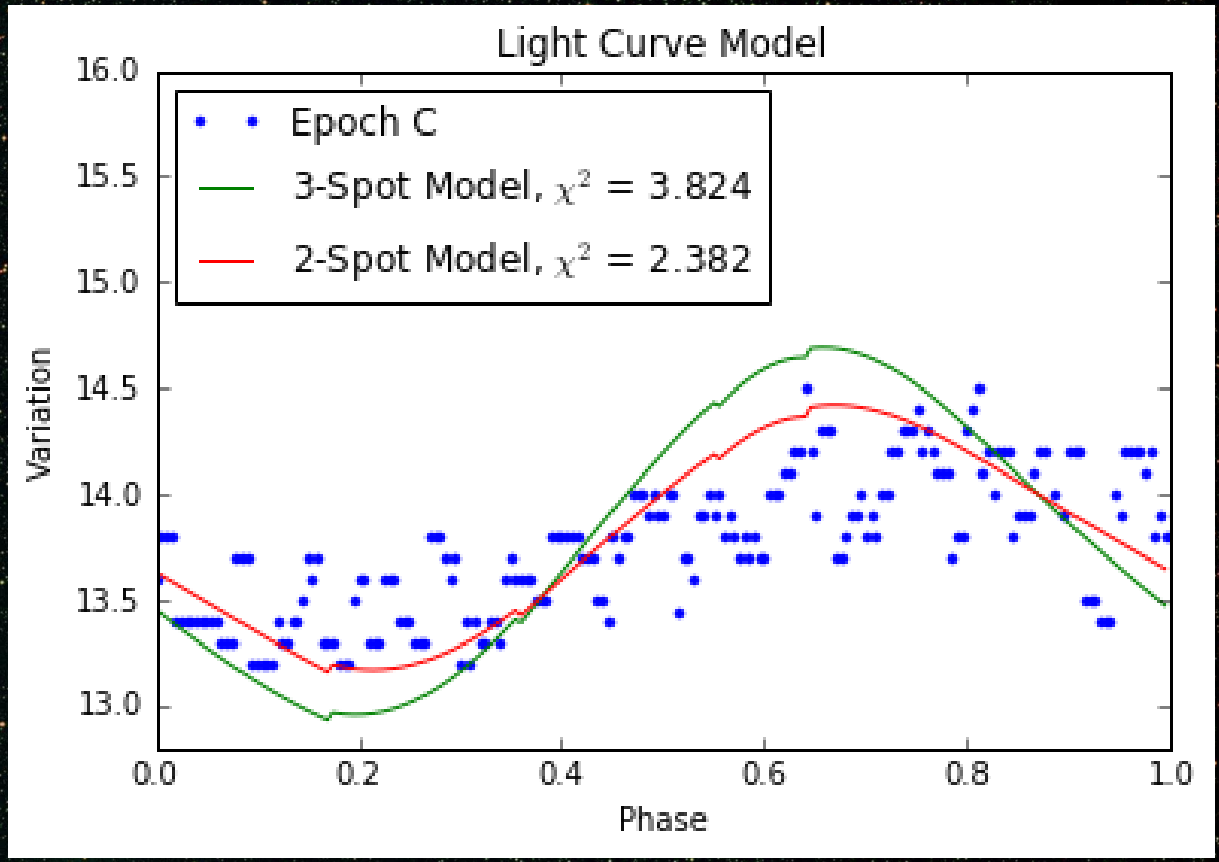
Synthetic data matching the observed temperatures of the proposed YSO would be used to run through several potential scenarios of what the spot(s) on that YSO might look like in terms of location, temperature, and size. The models can then be examined statistically.

A Chi-Square Test was then used to analyse the how well the model fits the observational data. This would indicate that the model generated was the most promising candidate for the physical phenomena that occurred during that period.

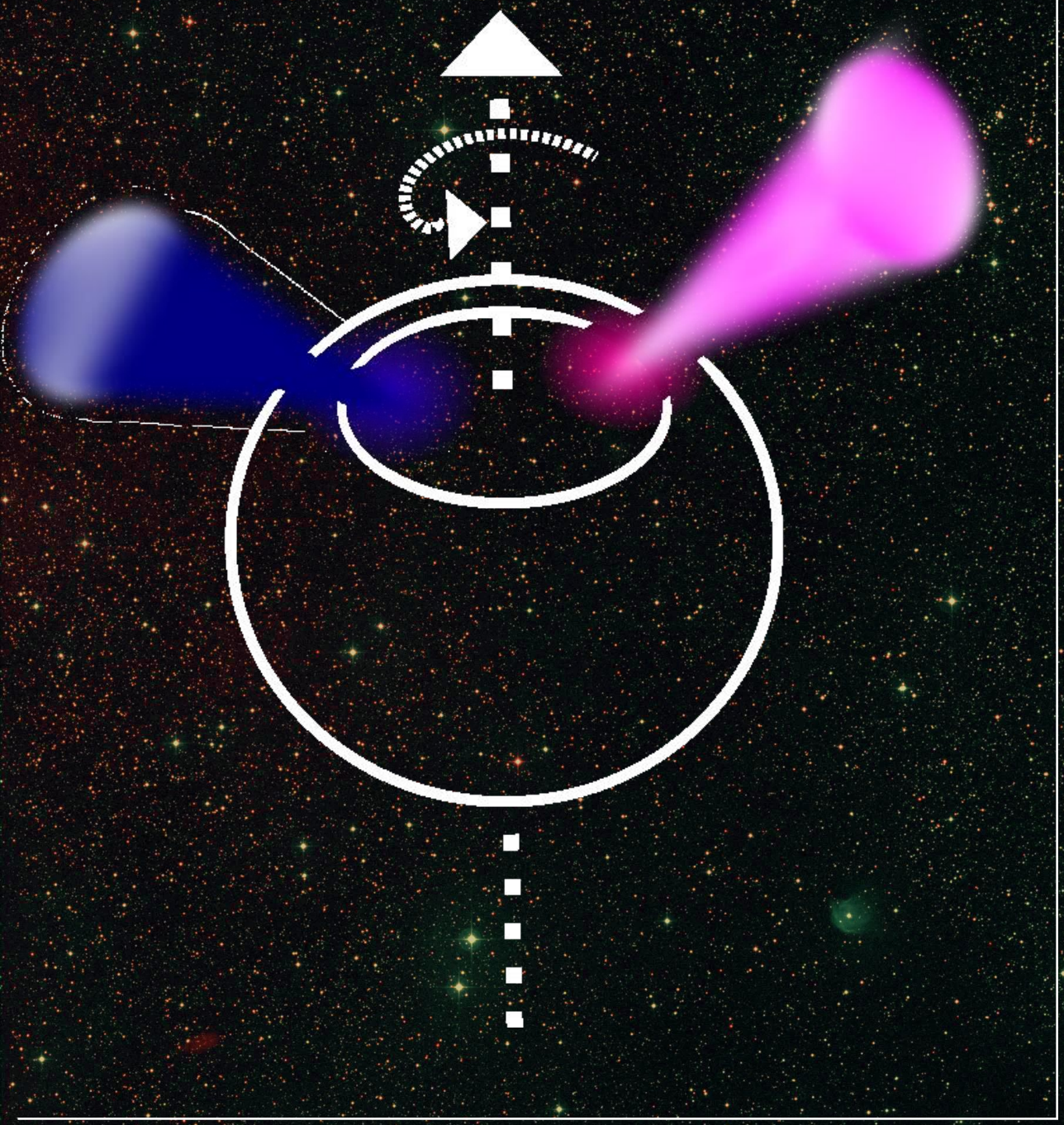
Results

The robust model is capable of recreating the light curves found in physical observations of YSOs – in particular, ASASSN-13db. An active star that exhibits both flares of heightened outburst powered by accretion material (~5,250 K) and periods of quiescence (~3,100 K).

The total spot coverage for both models in the figure add up to 40%, consistent with both the literature [2] and my preliminary findings generated by the photometric model. The thick sinusoidal nature of the observed data itself could suggest extended structures from a somewhat stable starspot that fluctuates with accretion rate, similar to EX Lupi [3].



Epoch C of ASASSN-13db's observational data plotted with the best fit 2-spot and 3-spot models.



Conclusions

The 2-spot model curve has spots located with 150 degree separation, suggesting dipolar accretion – disk accretion to a rotating star with a dipole magnetic field. In the case of ASASSN-13db the hot spots could be connected to magnetospheric funnel flows, as shown in the illustration. This indicates dominant accretion-powered hot spot activity, again reiterating literature findings [2].

[1] D.A. Aguilar, Centre for Astrophysics, Harvard (2015).
[2] A. Sicilia-Aguilar et al. Astronomy & Astrophysics. 607, A127 (2017).
[3] A. Sicilia-Aguilar et al. Astronomy & Astrophysics, 580 (2015).