Effects of a complex magnetic field on $\tau$ Sco’s X-ray production

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ADM model was developed to have an analytical approach for modeling the confined material.

upflow velocity:

\[ u(r) = V_\infty (1 - R_*/r)^\beta \]
Shock retreat was found to be a large factor in modeling the confined material in B-type stars.

- High mass loss rate, small cooling length, faster wind, stronger shock, stronger, harder X-rays.
- Low mass loss rate, large cooling length, slower wind, weaker shock, weaker, softer X-rays.

ud-Doula et al. 2014
Low-density shock-heated plasma produces emission spectra due to radiative cooling.
Shock heated plasma closer to the UV source will have more electrons in the intercombination level
τ Sco was observed to be more X-ray luminous than predicted.

τ Sco properties:
● B0.2V spectral type
● p=41 days
● B~500 G
τ Sco hosts a complex field

Donati et al. 2006, Kochukhov and Wade 2016
A field extrapolation was performed from the known surface magnetic field values and choosing the last closed field loop radius.

\[ R_{\text{source}} = 2 \, R_* \]
Shock temperatures are not high enough to produce the temperatures needed for observations.
With a small source radius we would expect X-ray variability which is not observed.

Ignace et al., 2010
Using f/i ratio the X-ray emission is from a radius of $\sim 2.65 \, R_*$
Changing the source radius allows for larger closed field loops and a lower mass loss rate.

Petit et al., in prep
The shock temperature becomes large with the larger source radius.
Summary

• Overluminosity likely caused by the complex field being assumed to be a dipole
• A larger source radius is needed to reproduce the spectral features

Future Work

• Determine the X-ray luminosity from the arbitrary field loop shock temperatures
• Constraining the source radius and mass loss rates
Thank you!