A Flexible Model for Investigating Properties of Starspots

Model Characterization

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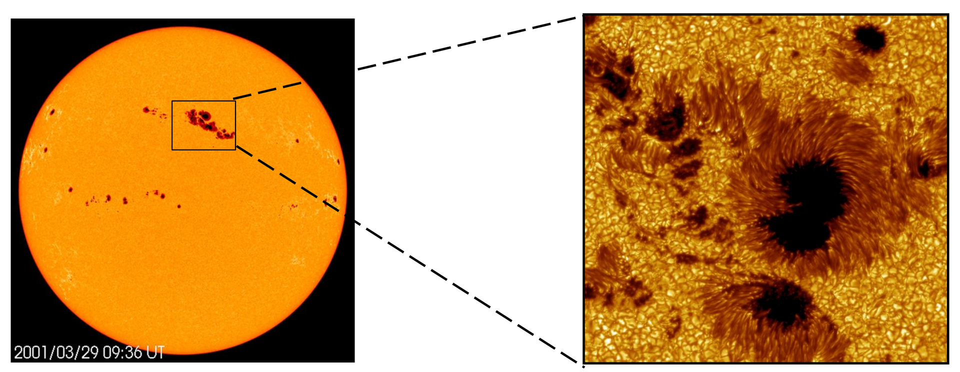
Introduction:

Noted discrepancies between Stellar Evolution Models and observed stellar properties lead us to focus on brightness asymmetries caused by magnetic fields for answers. Unfortunately there is a lack of complete understanding of the formation and affect of the starspots, brightness asymmetries. In congruence with a lack of substantial observational evidence on starspots forcing stars to restructure, we seek to explore questions formulated hundreds of years ago.



Motivation:

With improved stellar models updated to consider starspot physics, we can classify stars with more precision for the advancement of research, such as stellar evolution and planetary astronomy. The model can aid studies using GAIA data, Kepler data, and more.

Approach:

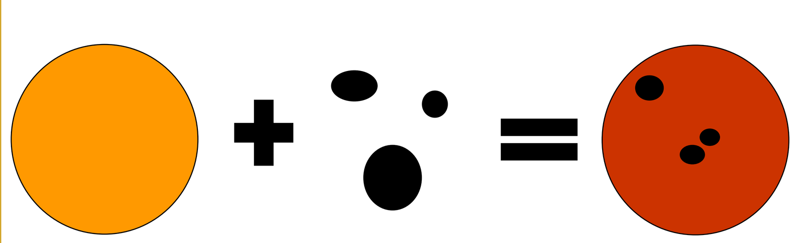
We develop a flexible model to predict how starspots affect a star's observable properties, to establish where within stars energy below a starspot becomes trapped and how the star responds.

$$\mathcal{L} = \xi\varphi^4\left[1 - \varrho\left(1 - \varpi^4\right)\right]$$

Luminosity ratio — Surface area ratio — Photospheric temperature ratio — Spot areal coverage — Spot temperature contrast

Morphologies Correlating Location and Duration of Trapped Energy:

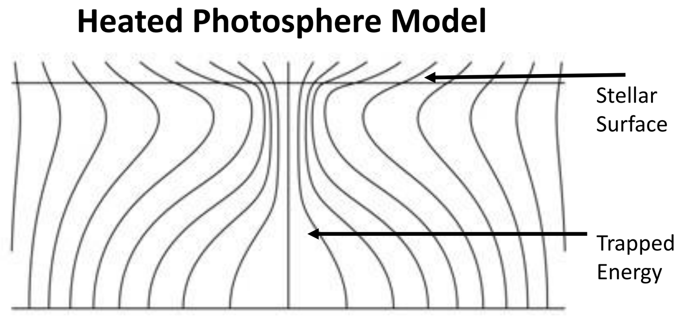
Short Timescale



Short timescale:

- Spots appear on the surface for a short amount of time to not grossly affect the properties of the host star.
- Noted to reduce Luminosity and typically produce a cooler, dimmer star.

Heated Photosphere Model

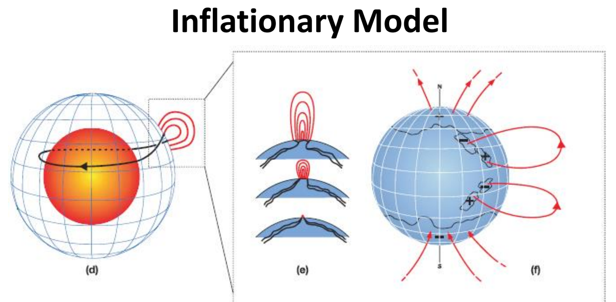


Kitchatinov & Mazur (2000)

Long timescale with a shallow formation:

- Spots appear for an extended amount of time trapping heat near the stellar surface which can escape through other radiative means.
- Noted to increase photospheric temperature producing a hotter and brighter star, opposite of typical anomalies seen with observation.

Inflationary Model



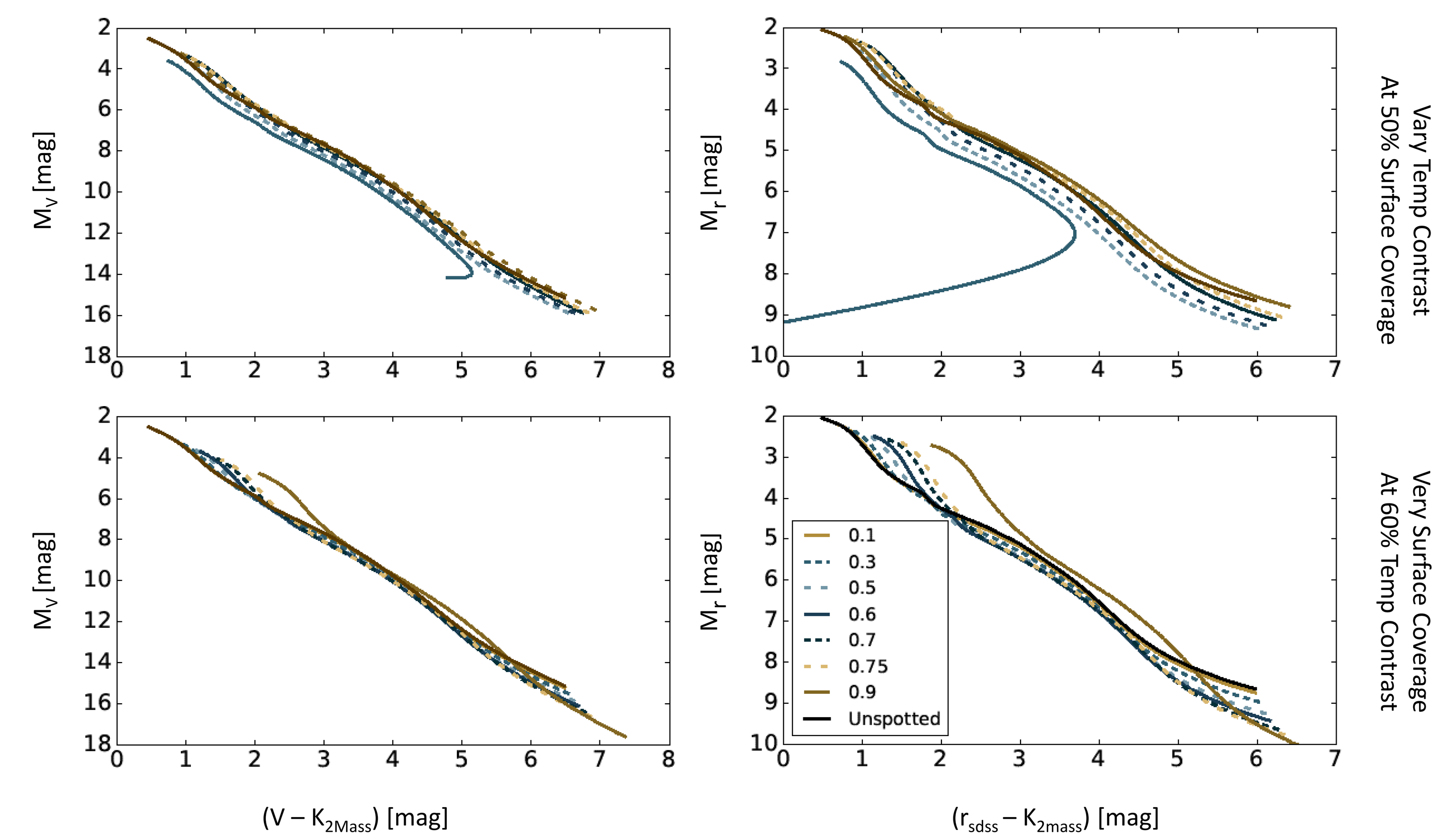
Dikpati & Gilman (2007)

Long timescale with a deep formation:

- Spots appear for an extended amount of time trapping energy deeper within the adiabatic layers
- Noted to increase the radius of the star producing a cooler, dimmer star.

Results and Systematic Analysis: Focus on 100 Myr Stars

Short Timescale



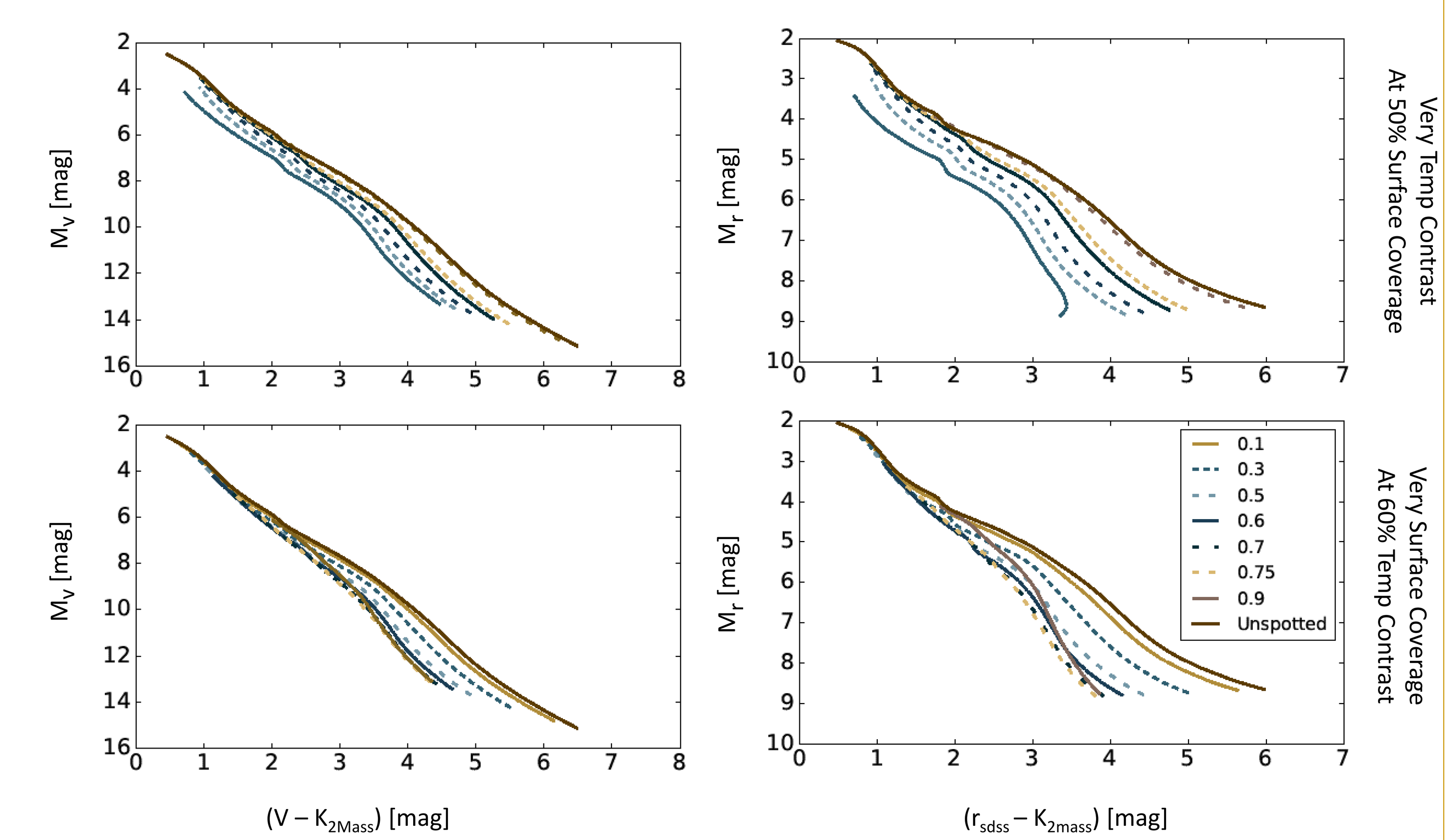
Short Timescale:

- Decrease in luminosity and temperature.
- Surface coverage changes lead stars to be visually dimmer and redder after 20% coverage.
- Initial severity of increased magnitudes and redder colors lessen with increasing temperature contrast. Background photosphere flux dominates.

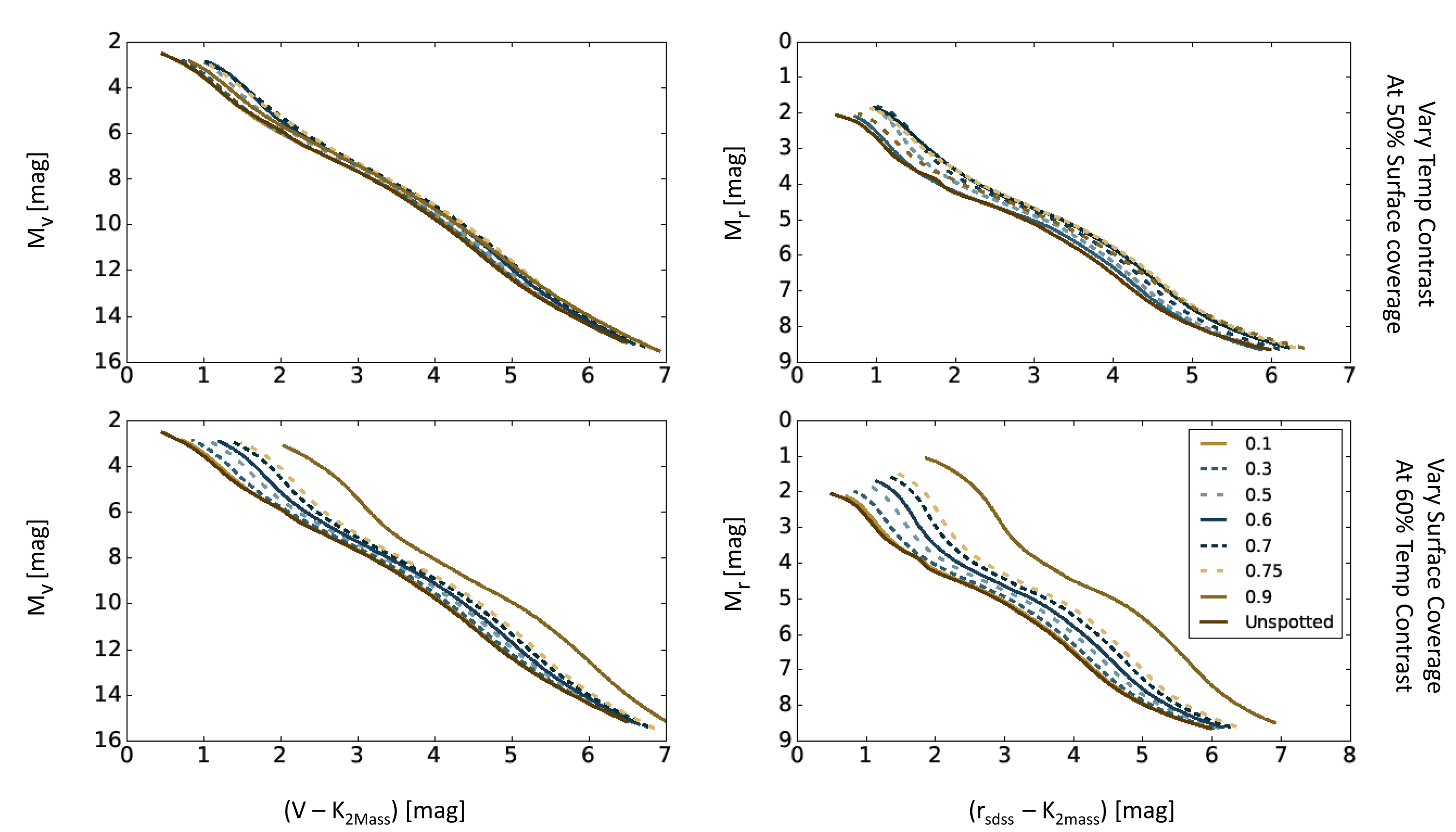
Heated Photosphere Model:

- As you increase surface coverage, stars compensate for the increasing flux blocked shifting the stars back toward the unspotted counterpart.
- Luminosity and temperature are conserved.
- Temperature Contrasts increasing past 20% leads to brighter bluer stars.
- Usual trends are opposite of trends found in short timescale and Inflationary.

Heated Photosphere



Inflationary Models



Inflationary Model:

- Inflationary model conserves luminosity but decreases in temperature.
- Increases in surface coverage over 20% lead to stars being larger and cooler
- Changes in temperature contrasts lead to the initial increase in magnitudes and shifts to redder colors, but as the contrasts deepens past 25% cooler, the shift returns towards to the unspotted counterpart.
- Usual trends are found to be similar to the short timescale.

Comparisons:

- Short and inflationary models show similar trends for certain temp contrasts
- Heated model adversely compares to other models.
- Extreme temperature contrasts, (0.3 and 0.1), and potential surface coverages, (0.8, 0.9), lead to photospheric temperatures reaching outside the validity of our models.

An expansion on the validity of the model in determining reasonable starspot parameters can be found at poster 85. A comparison of models to observed data focuses on actual young star clusters to determine best fit properties of spots and their affects on stellar parameters.

Future Focus and More

Jessica Hamilton is a second year undergraduate at the University of North Georgia. She is going into her second year of research under Dr. Gregory Feiden.

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References

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