Surface activity model of the eclipsing binary UV Leonis based on new spectrophotometric data

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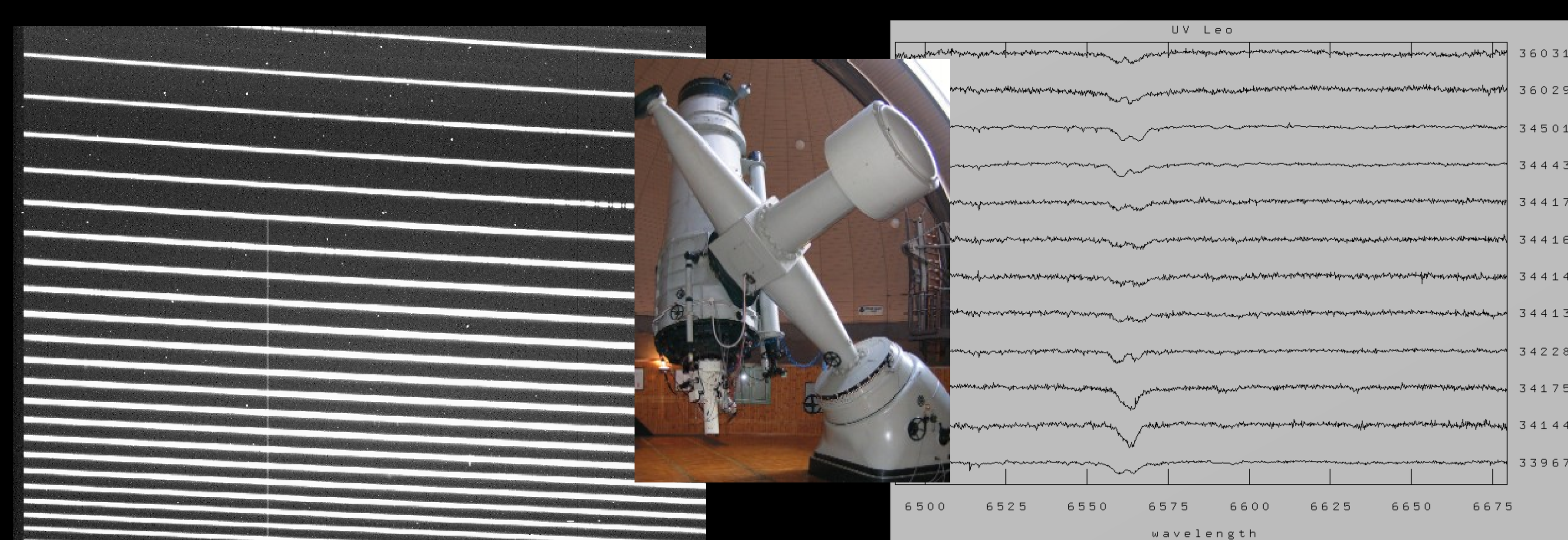
Abstract

UV Leonis is an eclipsing binary system consisting of two type G stars with a period of ~0.6 days. Evidence has been found of a period change in 1980, as previously reported by Wunder (1995) and Snyder (1998), but the exact nature and cause is still debatable. Stellar activity models have been explored by Frederik and Etzel (1996) but should be reexamined in light of more recent observations. Additional spectroscopic and photometric data were acquired by Kjurkchieva and Marchev (2007) but stellar activity was not analyzed. We propose a stellar activity model with two spots about the same size as in the previous model, but with spot-to-photosphere temperature ratios of about 0.95 instead of ~0.8. As opposed to two polar spots, our model consists of two migrating equatorial spots on the primary star.

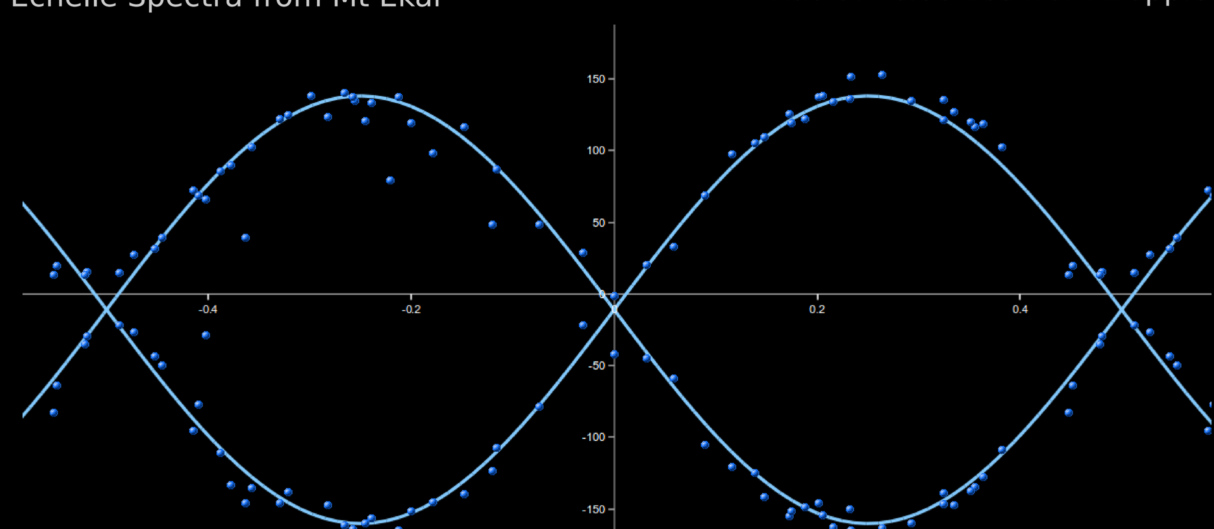
Data and Reduction

Forty nights of photometric data have been obtained from the 30" Automated Photoelectric Telescope in Patagonia, Arizona. We have also reduced echelle spectra from the 1.8m Mt. Ekar telescope in Asiago, Italy using IRAF packages echelle, apal, ecidentify, dispcor, continuum, and rvcorrect. Radial velocities were then determined using todcor.



Typical Echelle Spectra from Mt Ekar

Radial Velocities from Doppler Shifts



Radial Velocity (km/s)

Modeling

The eclipsing binary was modeled using PHOEBE (PHysics Of Eclipsing BinariEs). Semi-major axis and systemic velocity were constrained by fitting to the radial velocities. Additional parameters were then fit using photometric data from Frederik and Etzel, Mikuz et al., and the newly obtained APT observations.

Model Parameters

- Primary Star Effective Temp: 6000 K
- Secondary Star Effective Temp: 5850 K
- Period: 0.6 days
- Systemic Velocity: -11 km/s
- Semi Major Axis: 3.55 Solar Radii
- Inclination: 85 degrees

Stellar Activity Parameters

- Two migrating equatorial spots on the primary star
- Spot to Photosphere Ratio: ~0.95
- One polar spot to account for vertical shift between seasons

Stellar activity models were then fit individually to the separate seasons. A simple configuration with two to three migrating equatorial spots was used to account for the changing shape of the light curve. As in the case of the Crni Vrh observations (Mikuz et al.), polar spots were used to account for vertical displacement. We attempted to account for the sudden change in eclipse depth in the APT data with a third dark spot on the primary star.

We then compared the brightness of each season at all four quarter phases to try to determine if there is any underlying relationship (see figure on right).

References and Acknowledgements

Frederik, M.C.G, Etzel, P.B., 1996, AJ, 111, 2081
Kjurkchieva, D.P., Marchev, D.V., MNRAS, 381, 663
Mikuz et al., 2002, IBVS, 5338
Snyder, L.F., 1998, IBVS, 4624
Wunder, E., 1995, IBVS, 4179

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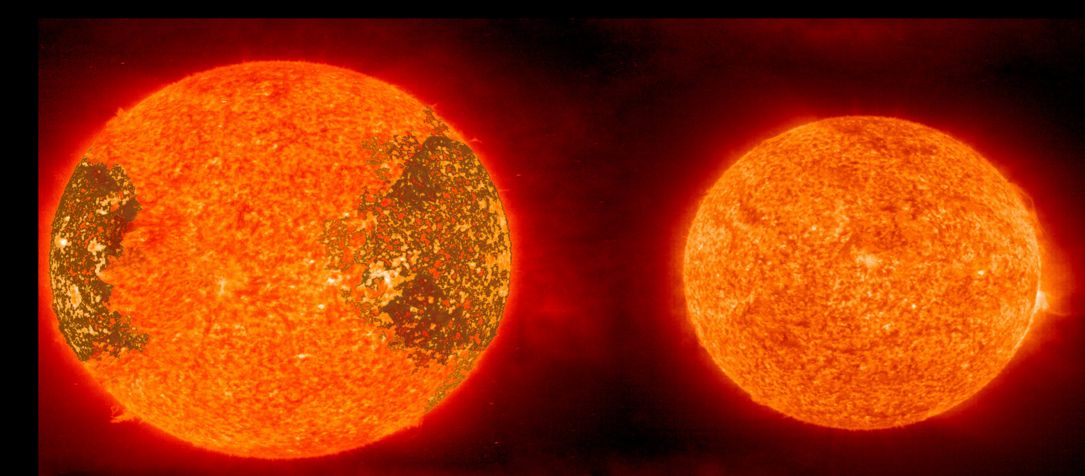
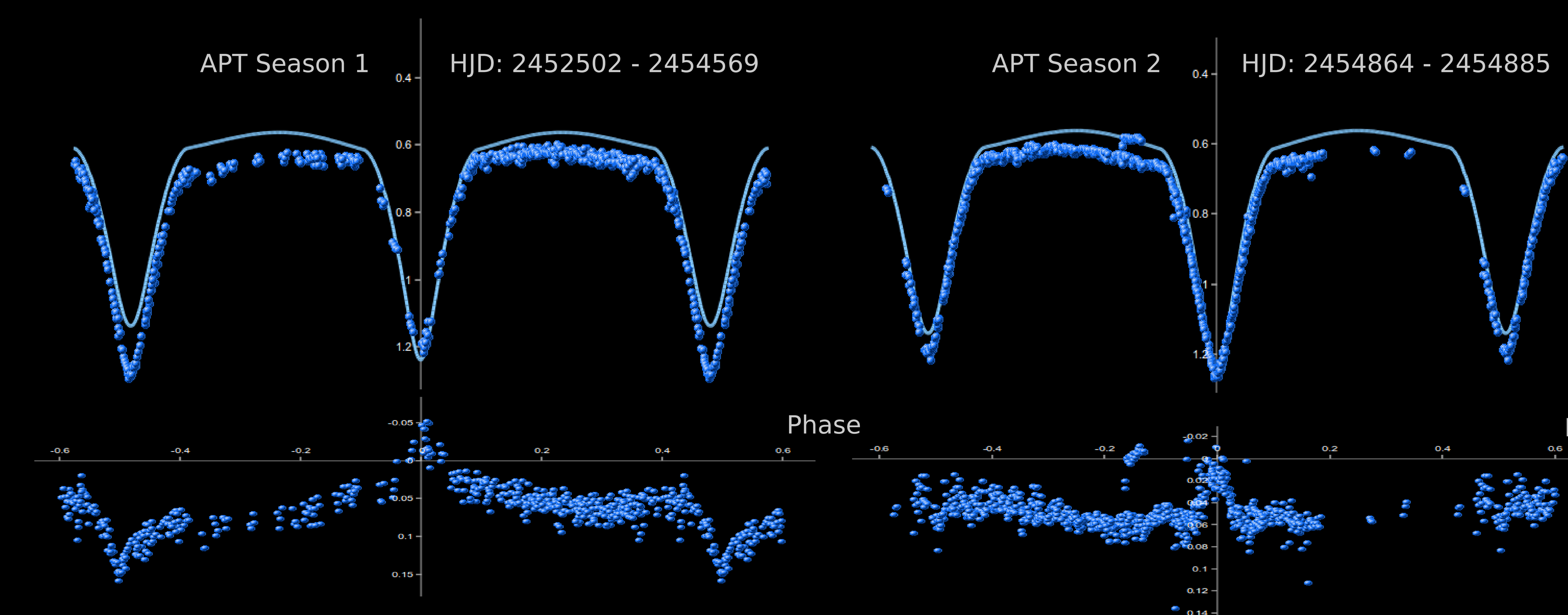
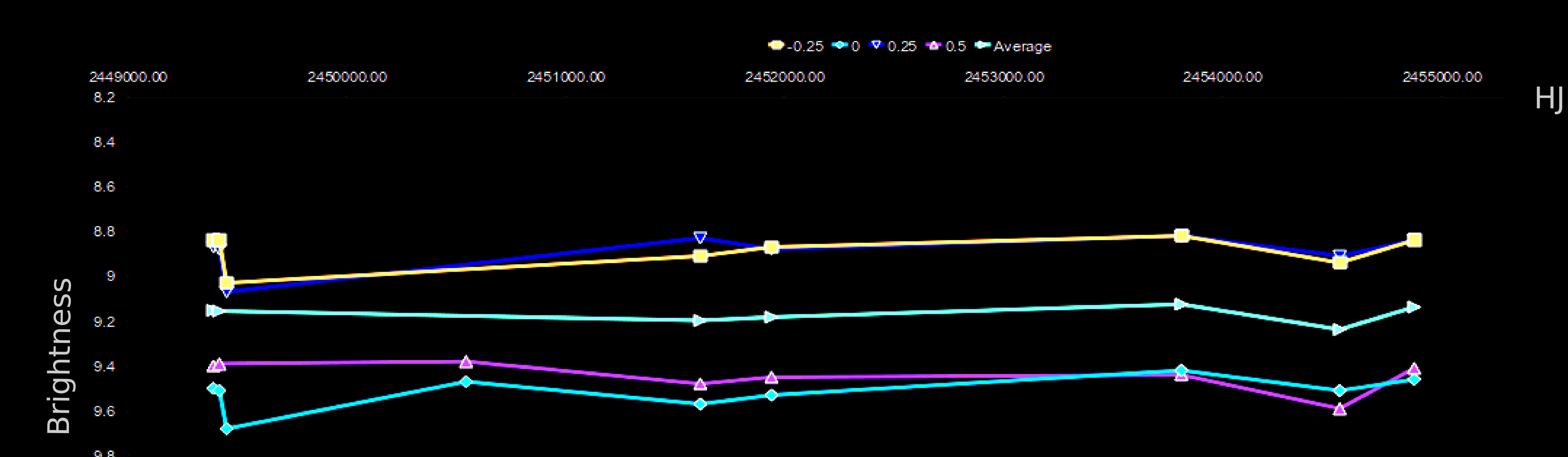
Stellar Activity Model



Stellar activity of UV Leo at quarter phase of the second season of APT data



Light curve observations of two APT seasons compared with the theoretical model before adding spots
Changes in the light curve shape are due to the migrating star spots



Brightness over time measured at quarter phases
Variations due to changing spot area

Conclusions and Future Research

Our spot model manages to account for most seasonal changes in the light curves over time. This however does not mean that it is the only possible solution and therefore is likely incorrect to some degree. What we have determined is that a stellar activity model is capable of explaining these changes, particularly the switch in eclipse depths seen in the most recent observations.

In the near future we are planning to further restrain the parameters on the stellar activity and eclipsing binary models. We will then run correlation tests to try to limit the solution down to a unique solution that will hopefully best describe the reality of the UV Leonis system. This in turn will allow us to cross-reference our results with those of the EBAI (Eclipsing Binaries with Artificial Intelligence) neural network system so that we can test and improve its accuracy.