Constraining the Mass Loss Geometry of Beta Lyrae

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Collaborators: Jennifer Hoffman, Nick Elias and Bruce Holenstein
Mass Loss in Binary Systems

- Tycho Supernova Remnant (Chandra)
- Artist’s conception of LH54-425
- Explosions
- Stellar Winds
- Roche lobe transfer
Beta Lyrae: What We Know

Polar View

Edge On View

Harmanec, P. 2002, AN, 323, 87
Beta Lyrae: What We Know

V Band Light Curve

IR H band: 1.5 to 1.8\(\mu\)m

Where is the mass lost?

How much matter is in the jets?

What are the characteristics of the jets and mass stream?
The Data Set

HPOL: 14 Reticon (3200-7500Å)
53-55 CCD (3200-10,500Å)

Appenzeller & Hiltner (1969): 37 $B$
127 $V$

Flower & Cook Observatory: 19 $B$
88 $V$
17 $R$

$V$ Band Polarized Light Curve

Zhao et. al. (2008): 
253° ± 1.97° 
251° ± 1.83°

HPOL Observations: 
164° (± 1°) + 90° = 254°

Secondary Eclipse in Polarized Light!
Proposed Geometry
Hot Spot $\%Q_p$ Size Estimate

<table>
<thead>
<tr>
<th>Band</th>
<th>$2^{nd}$ary Phase</th>
<th>$%Q_p$ Hot Spot Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>0.449</td>
<td>28 $R_{\text{sun}}$</td>
</tr>
<tr>
<td>V</td>
<td>0.457</td>
<td>28 $R_{\text{sun}}$</td>
</tr>
<tr>
<td>R</td>
<td>0.482</td>
<td>40 $R_{\text{sun}}$</td>
</tr>
<tr>
<td>I</td>
<td>0.455</td>
<td>40 $R_{\text{sun}}$</td>
</tr>
</tbody>
</table>
## Hot Spot PA Size Estimate

### Diagram

- **Phase**: 0.174
- **HPOL Reticon**: 16 $R_{\text{sun}}$
- **HPOL CCD**: 60 $R_{\text{sun}}$

### Table

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<thead>
<tr>
<th>Band</th>
<th>Size in Phase</th>
<th>Max Hot Spot Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>0.14</td>
<td>48 $R_{\text{sun}}$</td>
</tr>
<tr>
<td>V</td>
<td>0.16</td>
<td>55 $R_{\text{sun}}$</td>
</tr>
<tr>
<td>R</td>
<td>0.125</td>
<td>43 $R_{\text{sun}}$</td>
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<tr>
<td>I</td>
<td>0.09</td>
<td>31 $R_{\text{sun}}$</td>
</tr>
</tbody>
</table>
Hα Line
Conclusions

Line polarimetry suggests origin of jets is not hot spot

Do other Roche lobe-transfer systems show secondary eclipse effect?

What does the jet location mean in terms of evolution?

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<thead>
<tr>
<th>Band</th>
<th>PA Hot Spot Size</th>
<th>%Q_p Hot Spot Size</th>
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</thead>
<tbody>
<tr>
<td>B</td>
<td>48 R_{sun}</td>
<td>28 R_{sun}</td>
</tr>
<tr>
<td>V</td>
<td>55 R_{sun}</td>
<td>28 R_{sun}</td>
</tr>
<tr>
<td>R</td>
<td>43 R_{sun}</td>
<td>40 R_{sun}</td>
</tr>
<tr>
<td>I</td>
<td>21 R_{sun}</td>
<td>40 R_{sun}</td>
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</table>

Future Work:
- X-ray data
- Line polarization
- Better monitoring near secondary eclipse
- Period Analysis

Acknowledgements:
Jennifer Hoffman
Marilyn R. Meade
Ken Nordsieck
Brian Babler
Nick Elias
Hot Spot Simple Model Size Estimate

\[ \frac{R_t}{2} \]

\[ H \]

\[ A_{\text{el}} \]

\[ H_D \]

\[ D_D \]

<table>
<thead>
<tr>
<th>Band</th>
<th>( q_{\text{DC}} )</th>
<th>( q_{\min} )</th>
<th>( H_{\text{SM}} )</th>
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</thead>
<tbody>
<tr>
<td>B</td>
<td>0.187</td>
<td>0.041</td>
<td>37</td>
</tr>
<tr>
<td>V</td>
<td>0.179</td>
<td>0.081</td>
<td>23</td>
</tr>
<tr>
<td>R</td>
<td>0.171</td>
<td>0.074</td>
<td>24</td>
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<tr>
<td>I</td>
<td>0.140</td>
<td>0.076</td>
<td>19</td>
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</tbody>
</table>
U Band

Inferred scattering geometry

UV light scatters in jet

Visible light scatters in disk

Position angle (°)

Wavelength (Å)
B Band

![Graph showing normalized flux and position angle in the B band.](image-url)
Projected Polarized Flux

![Projected Polarized Flux Graph]

- Normalized Flux
- Projected Polarized Flux
- Phase

Graph labels: B, V, R, I
V Band Polarization and $\%U_p$