The Evolutionary State of HR 7955

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HR 7955: Coravel, CHARA, NPOI

Spectroscopic orbit from Griffin (1999):

$$(V_A, V_B)$$ for 38 epochs
Inclination $i = 23^\circ$ inferred from assuming
masses $\sim 1.3 \ M_{\text{sol}}$ from spectral type (F8 V).
Mass ratio $q = M_A/M_B = 1.025$, but $\Delta m_V \approx 0.4$.

Interferometric orbit from Farrington et al. (2010):

60 SFP observations
$i = 24.5^\circ \pm 3.1^\circ$ yields $M_A, M_B = 1.07, 1.04 \ M_{\text{sol}}$.
($\sigma_{\sin i}/\sin i = 0.12$, so $\sigma_M \sim 0.4$ for both.)

NPOI data

28 nights with two to six baselines
$i = 23^\circ \pm 3^\circ$ yields $M_A, M_B = 1.30, 1.26 \ M_{\text{sol}}$, both $\pm 0.5 \ M_{\text{sol}}$. 
HR 7955: Coravel, CHARA, NPOI

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\[ i = 23^\circ \pm 3^\circ \] yields \( M_A, M_B = 1.30, 1.26 \ M_{\text{sol}}, \)
both \( \pm 0.5 \ M_{\text{sol}} \):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P )</td>
<td>523.35 days (Griffin)</td>
</tr>
<tr>
<td>( a )</td>
<td>63.7 \pm 0.4 mas</td>
</tr>
<tr>
<td>( e )</td>
<td>0.547 (Griffin)</td>
</tr>
<tr>
<td>( i )</td>
<td>23 \pm 3 deg</td>
</tr>
<tr>
<td>( M_{\text{star}} )</td>
<td>1.3 \pm 0.3 ( M_{\odot} ) for both</td>
</tr>
<tr>
<td>Mass ratio</td>
<td>1.025 \pm 0.015 (Griffin)</td>
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</tbody>
</table>
HR 7955: Colors & magnitudes

NPOI magnitude differences:
Data in 16 channels, 0.55 – 0.85 μm
\( \Delta M_V = 0.85, \Delta M_I = 0.34 \)

Primary: \( M_{V,A}, (R - I)_A \Rightarrow M_A \approx 1.53 \, M_\odot \, @ \approx 1.6 \, \text{Gyr} \)

Secondary: \( M_{V,B}, (R - I)_B \Rightarrow M_B \approx 0.60 \, M_\odot \, @ \approx 3.6 \, \text{Gyr}, \)

The combination of mass ratio and brightness ratio barely fits with evolutionary models — and then only with \( q = M_A/M_B \approx 1.3. \)

Masses:
\( M_{V,A}, (R - I)_A \Rightarrow M_A \approx 1.53 \, M_\odot \, @ \approx 1.6 \, \text{Gyr} \)

but

\( M_{V,B}, (R - I)_B \Rightarrow M_B \approx 0.60 \, M_\odot \, @ \approx 3.6 \, \text{Gyr}, \)

way undermassive and too old!

Note that \( q = 1.025 \pm 0.015 \Rightarrow M_B = 1.49 \pm 0.02 \, M_\odot \)
HR 7955: Colors & magnitudes

NPOI magnitude differences:
Data in 16 channels, 0.55 – 0.85 μm
ΔMᵥ = 0.85, ΔMᵢ = 0.34

Primary: \( Mᵥ,A = 2.72, (R – I)_A = 0.25 \)
Secondary: \( Mᵥ,B = 3.65, (R – I)_B = 0.32 \)

Masses:
\( Mᵥ,A, (R – I)_A \Rightarrow M_A \approx 1.53 \ M_\odot \ @ \approx 1.6 \ Gyr \)

If we move B to the 1.6 Gyr isochrone:
\( (R – I)_B \rightarrow 0.28 \Rightarrow M_B = 1.30 \ M_\odot \)
(color is okay, mass is too small)
— or —
\( Mᵥ,B \rightarrow 4.41 \Rightarrow M_B = 1.14 \ M_\odot \)
(much too faint, mass is even smaller)

The combination of mass ratio and brightness ratio barely fits with evolutionary models — and then only with \( q = M_A/M_B \approx 1.3 \).
HR 7955: A third body?

The secondary could be multiple, but the parameter space is constrained:

Stability: \( P_{\text{inner}} < 100 \text{ days} \)

Radial velocities: Griffin \((O - C) \approx 0.2 \text{ km/s} \)
\( \frac{M_{\text{Bb}}}{M_{\text{Ba}}} < 0.1 \) (component Bb can’t be too big) — or \( i \sim 0^\circ \)

Magnitudes: \( \Delta m_V \approx 0.85 \Rightarrow \frac{M_A}{M_{\text{Ba}}} < 1.3 \) (component Ba can’t be too small)

Astrometric perturbations? Revisit when the orbit is improved.