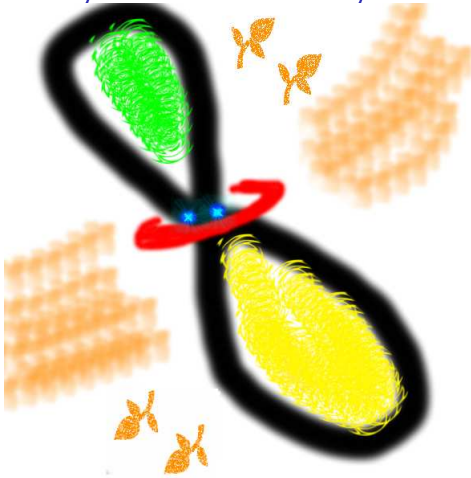
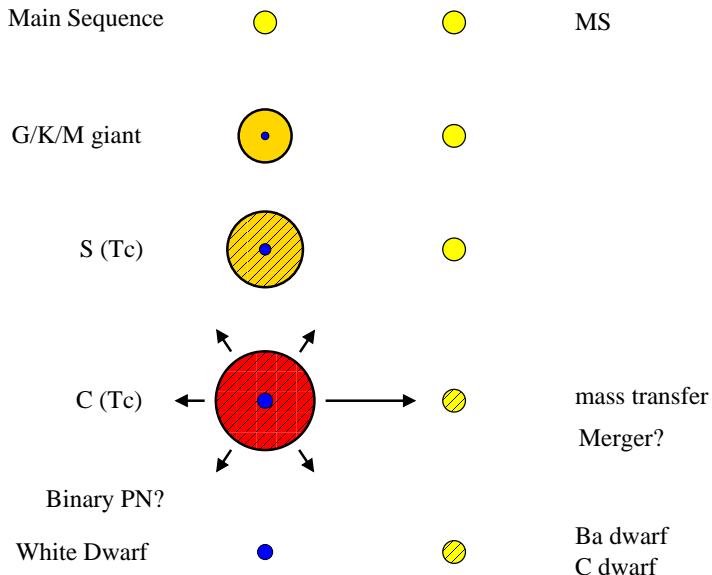


Binary AGB Nucleosynthesis

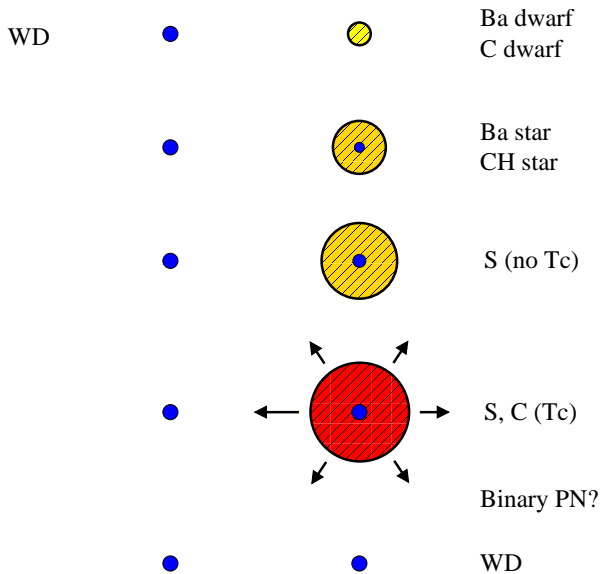


Rob Izzard
Utrecht University

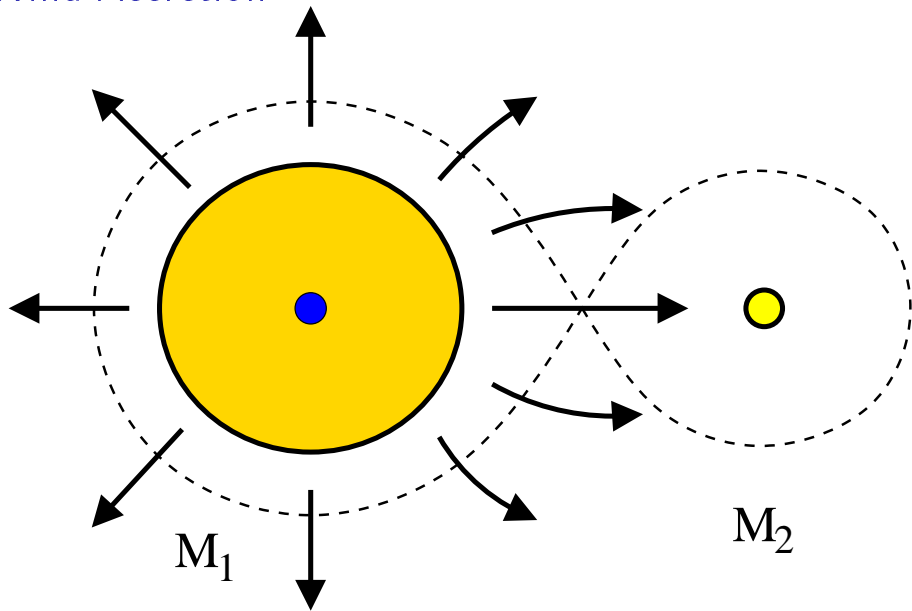
Mass Transfer Scenarios (Primary)



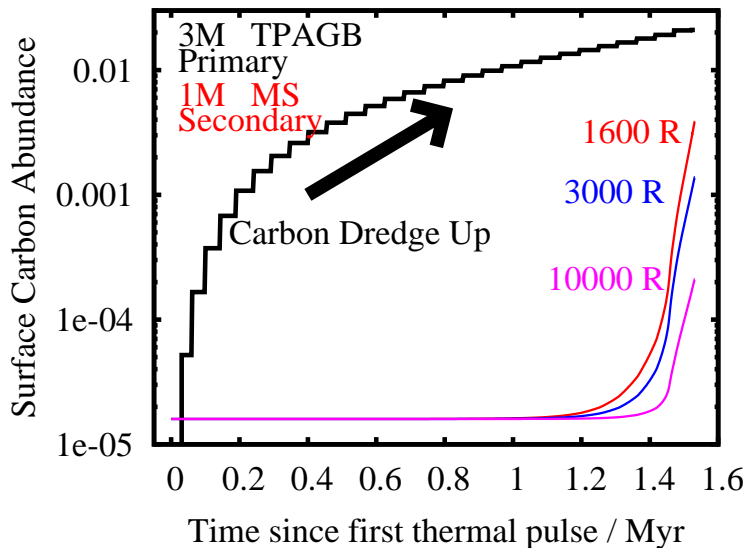
Mass Transfer Scenarios (Secondary)



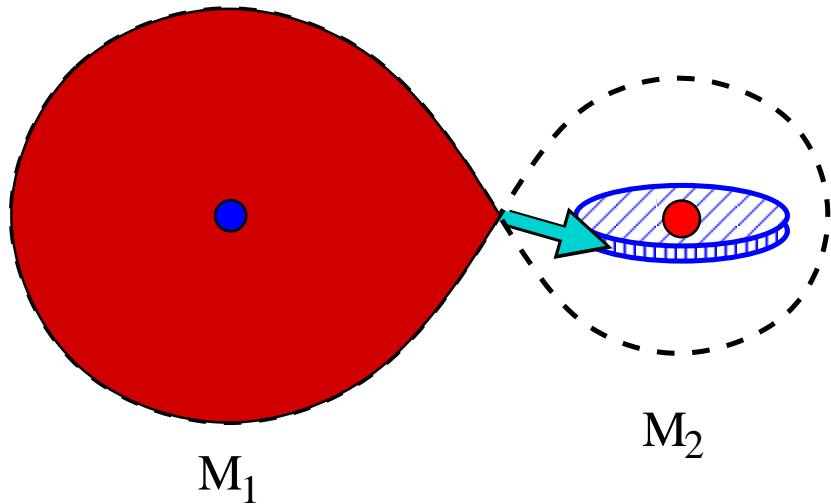
Wind Accretion



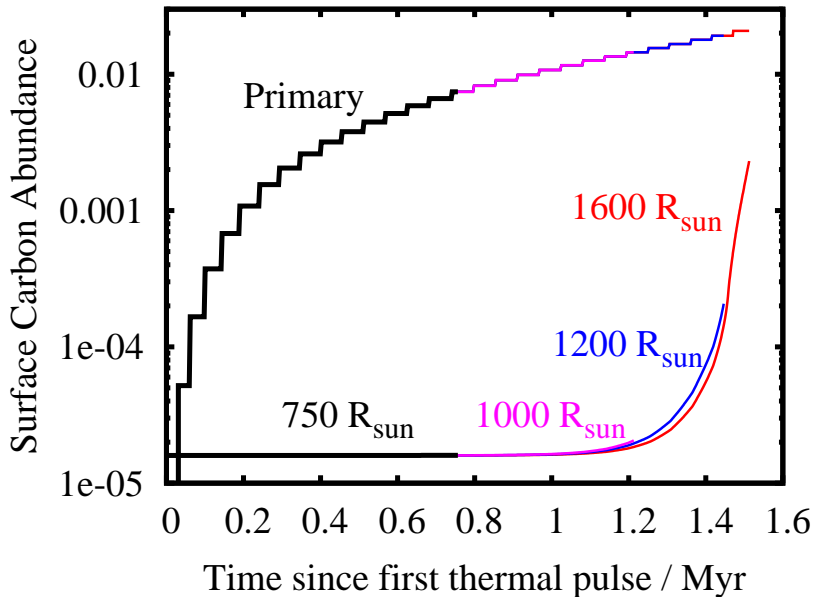
Wind Accretion: $3 + 1 M_{\odot}$, $Z = 0.004$



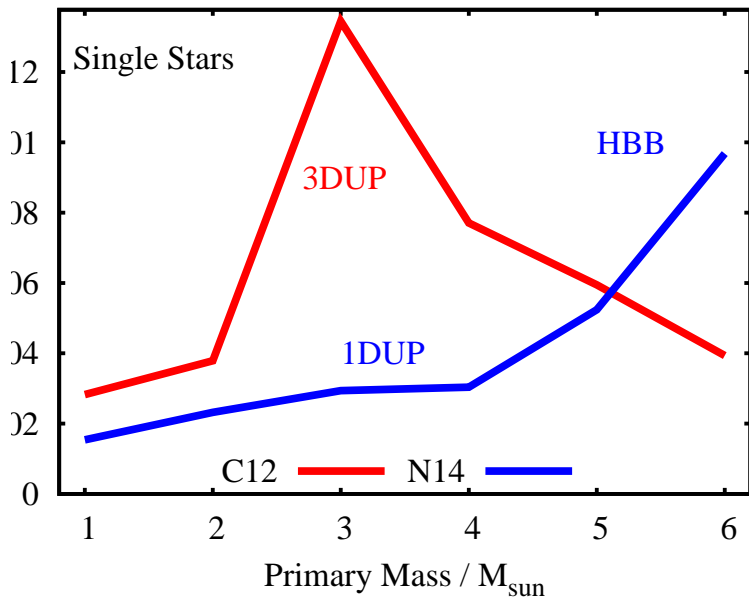
Roche Lobe Overflow



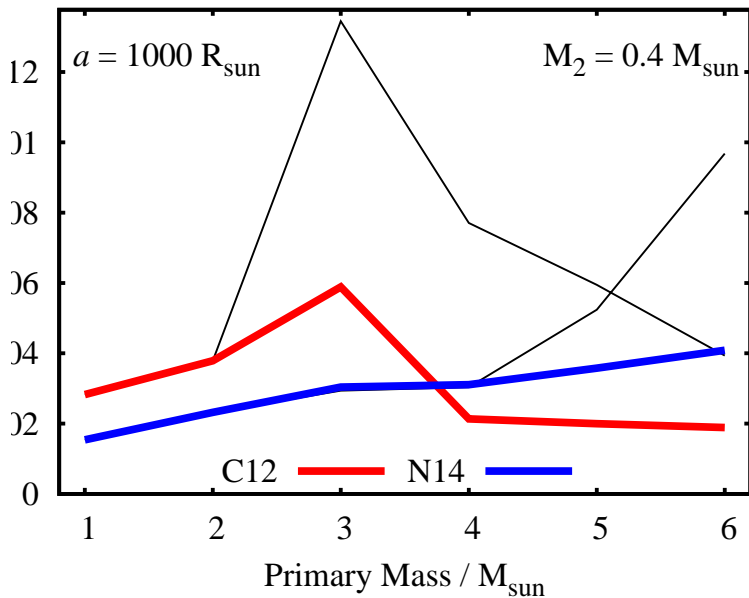
RLOF $3 + 1 M_{\odot}$, $Z = 0.004$



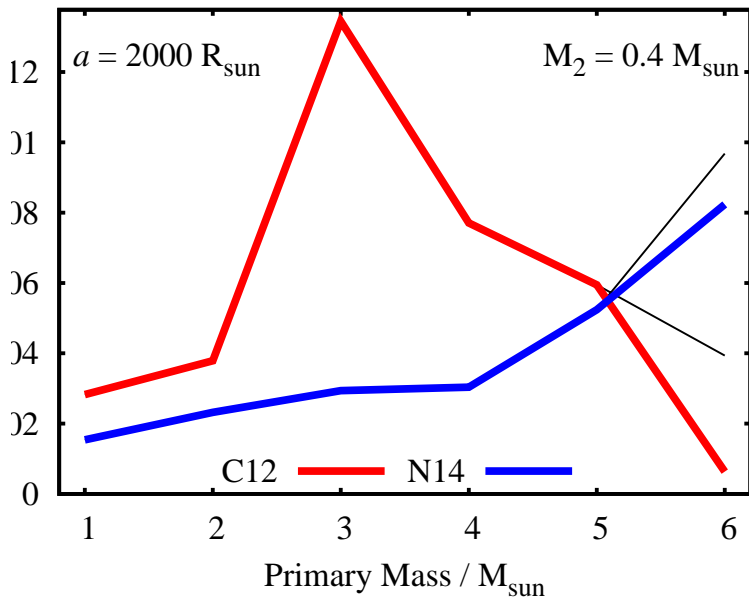
End-AGB C and N $Z = 0.02$



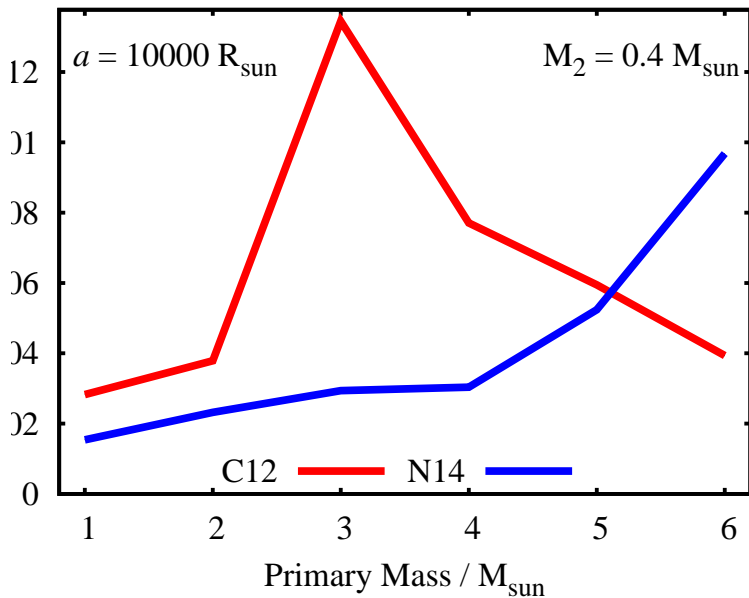
End-AGB C and N



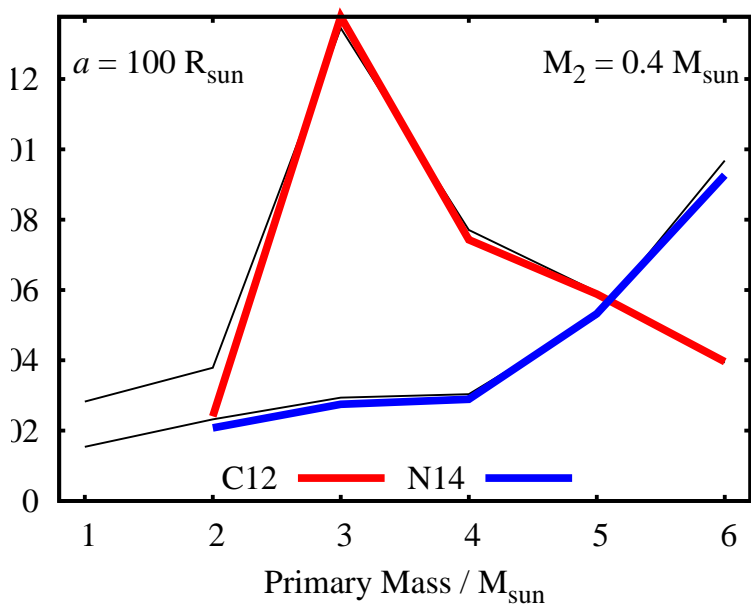
End-AGB C and N



End-AGB C and N



End-AGB C and N: Close→mergers(?)



Global Effect On AGB Yields

Less nuclear processing

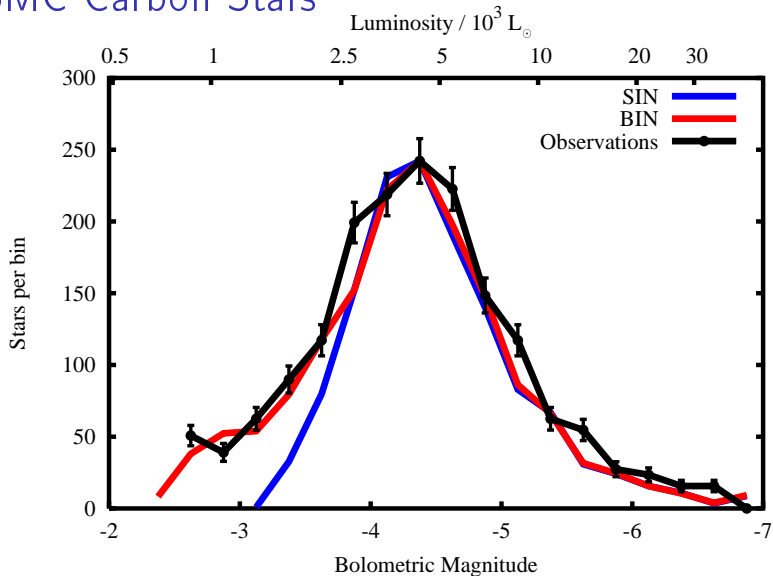
- ▶ More H
- ▶ Less He, C, N, Ne, Mg, Ba
etc.

Second hand evidence: Companions to AGB Stars

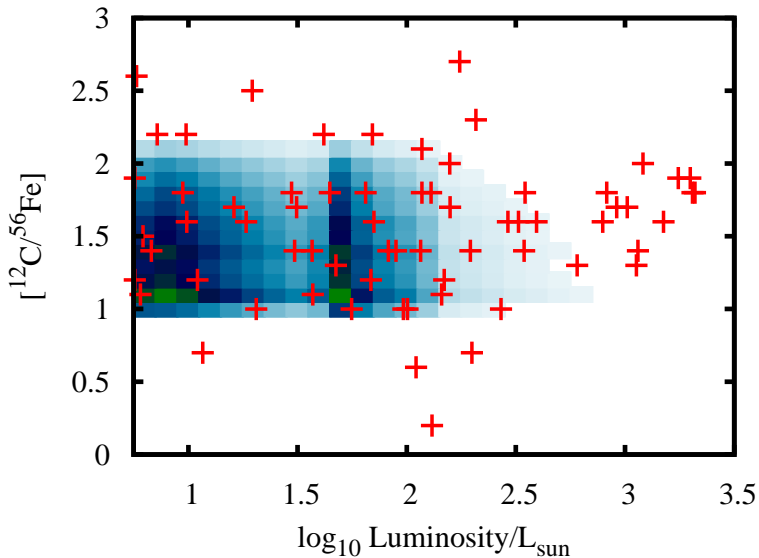
Much of our understanding comes companion stars
which *accrete AGB material*: a few examples. . .

- ▶ Extrinsic carbon stars (CH stars)
- ▶ CEMPs
- ▶ Barium stars

SMC Carbon Stars

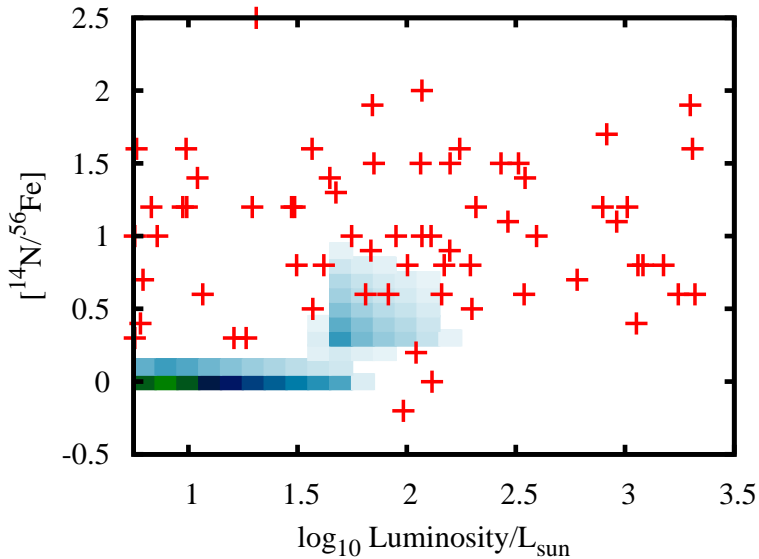


Halo Carbon Stars : C vs L

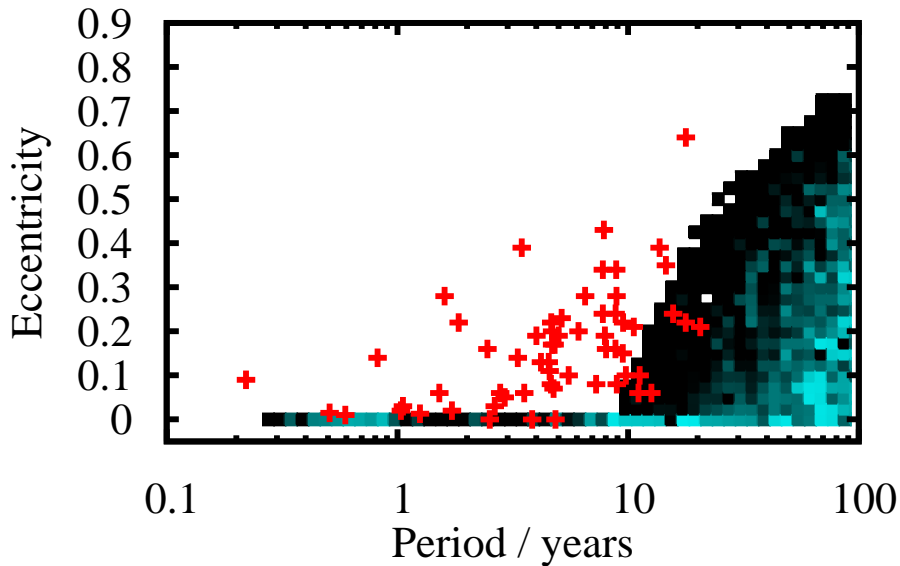


Data from Lucatello, Beers, Christlieb 2006 ApJL 652,L37

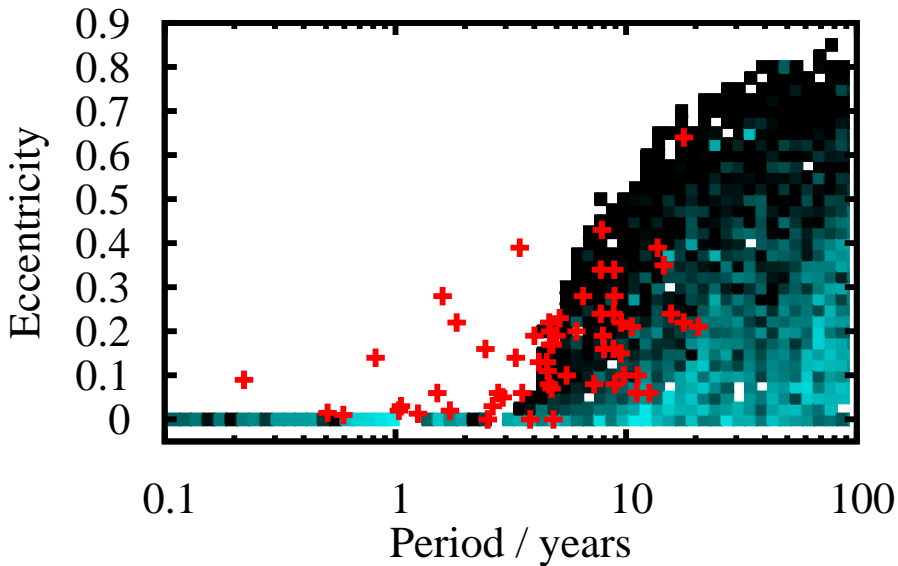
Halo Carbon Stars : N vs L



Barium Stars: Old problem



Barium Stars: New solution (Axel Bonacic)



Try It Yourself

<http://www.phys.uu.nl/~izzard/cgi-bin/binary2.cgi>

binary_c/nucsyn frontend - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/~izzard/cgi-bin/binary2.cgi binary planetary nebula

binary_c/nucsy... Period - Separati... Gmail - Inbox Problem loading ... Author Query Re...

binary_c/nucsyn

A frontend to the binary_c/nucsyn code

Mass of star 1	<input type="text" value="14"/>	(M _{sun} , 0.1-100)
Mass of star 2	<input type="text" value="6"/>	(M _{sun} , 0.1-100)
Maximum Evolution Time	<input type="text" value="13700"/>	(In Myr)
Separation <input type="text" value="100"/>	<input type="text" value="100"/>	(in R _{sun} or days)
Metallicity Z 0.0001 - 0.03 0.02 is Population I	<input type="text" value="0.02"/>	
Eccentricity	<input type="text" value="0.0"/>	0-1
Black Hole Prescription	<input type="text" value="Hurley2002"/>	
WR Wind Loss Prescription	<input type="text" value="Hurley2002"/>	boost factor <input type="text" value="1.0"/>
TPAGB Wind Loss Prescription	<input type="text" value="Karakas2002"/>	Mira Superwind at <input type="text" value="500"/> days (Karakas2002 only)

Try It Yourself

<http://www.phys.uu.nl/~izzard/cgi-bin/binary2.cgi>

binary_c/nucsyn : results - Mozilla Firefox

http://localhost/~izzard/cgi-bin/binary2.cgi

binary_c/nucsyn : results

binary_c/nucsyn results

Evolution Time (MYr)	Star 1 mass (M_sun)	Star 2 mass (M_sun)	Star 1 type	Star 2 type	Separation (R_sun)	Period	Eccentricity	Star 1 R/ROL	Star 2 R/ROL	What's happening?
0.0000	14.000	6.000	Main Sequence	Main Sequence	100.000	25.92	0.00	0.106	0.095	In the beginning there was a star...
14.0936	13.718	6.002	Hertzsprung Gap	Main Sequence	101.340	26.44	0.00	0.256	0.103	Stellar Type Change

← 0.5 AU →
25.9 days

← 0.5 AU →
26.6 days

Conclusions

- ▶ Binary stars reduce the effect of third dredge up and hot bottom burning
 - ▶ Final abundances and yields: reduced nuclear processing.
- ▶ Not simple! RLOF/wind, mergers/common envelope ejection
- ▶ Quantitative...?
- ▶ Secondary accretion: Some progress with Ba stars
- ▶ CEMPs are a problem (different solution?)
- ▶ PNe abundances can help constrain dredge up and HBB?

<http://www.phys.uu.nl/~izzard/cgi-bin/binary2.cgi>