Carbon Stars:
MATISSE Data & DARWIN Models

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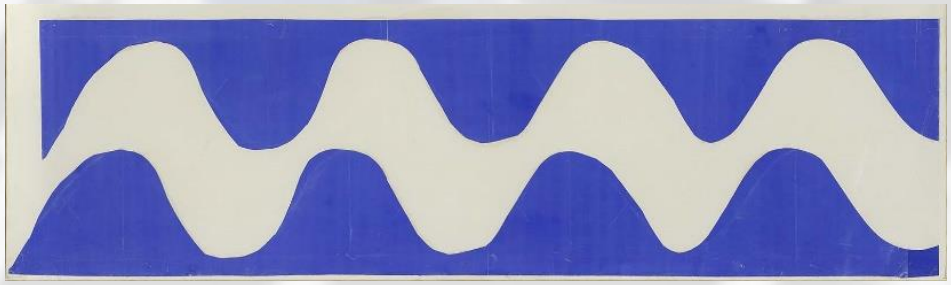
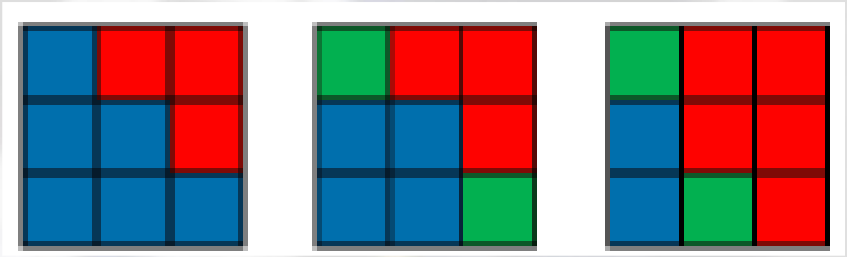


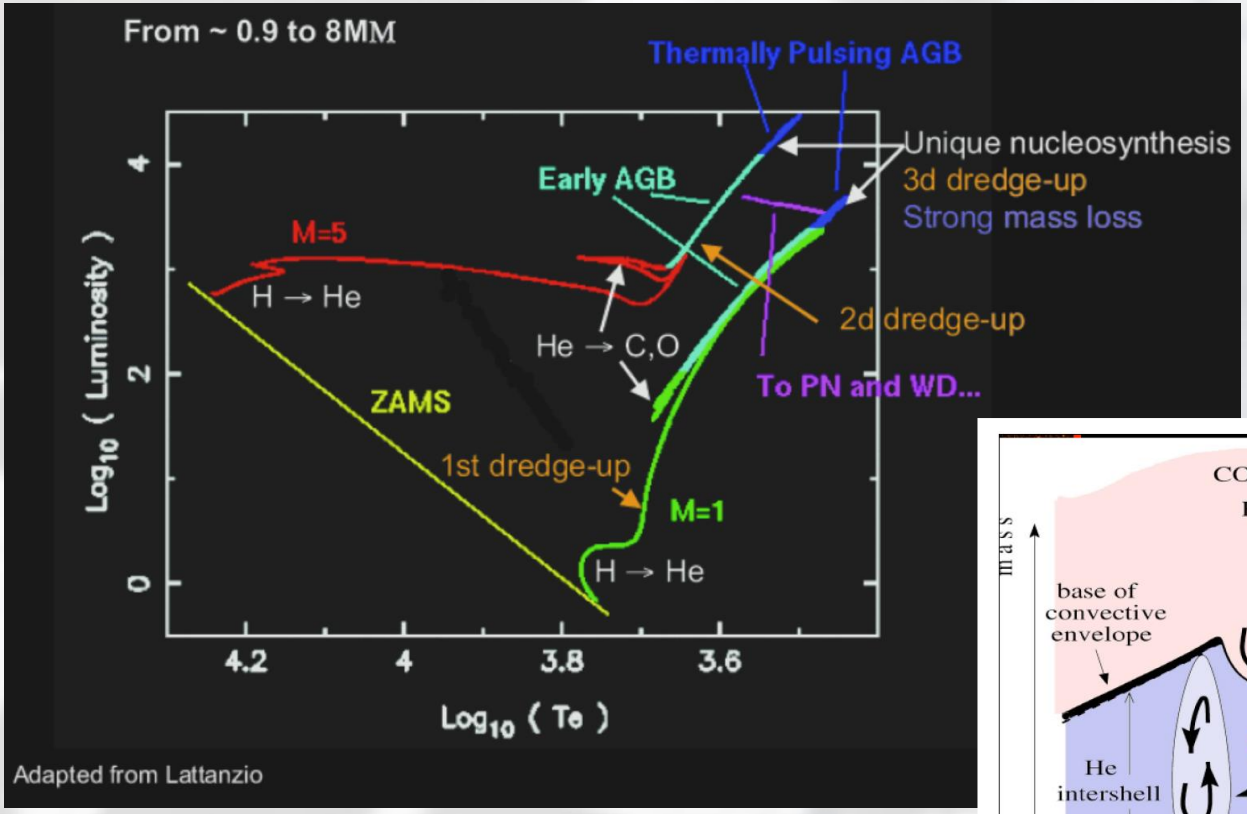
La vague Henri Matisse 1952
tresors.nice.fr

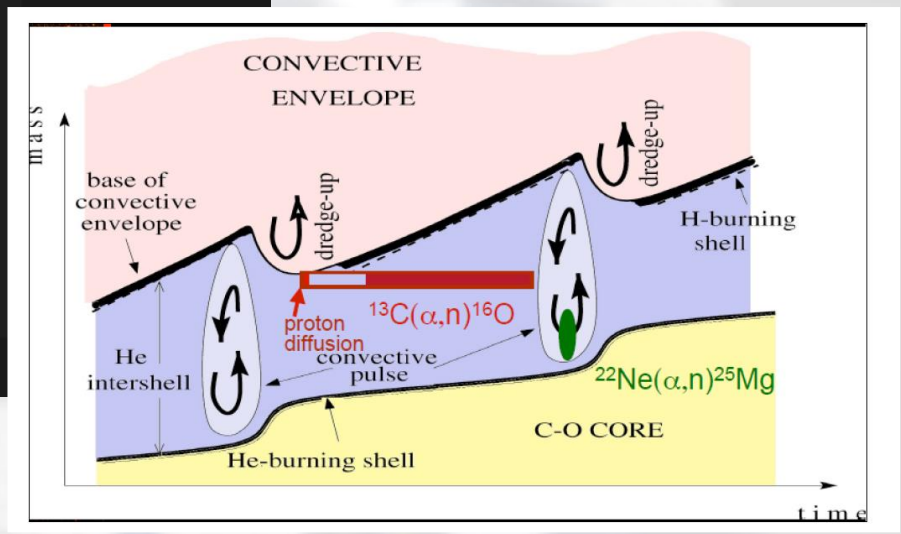


Eriksson+ (2022)

Thanks to

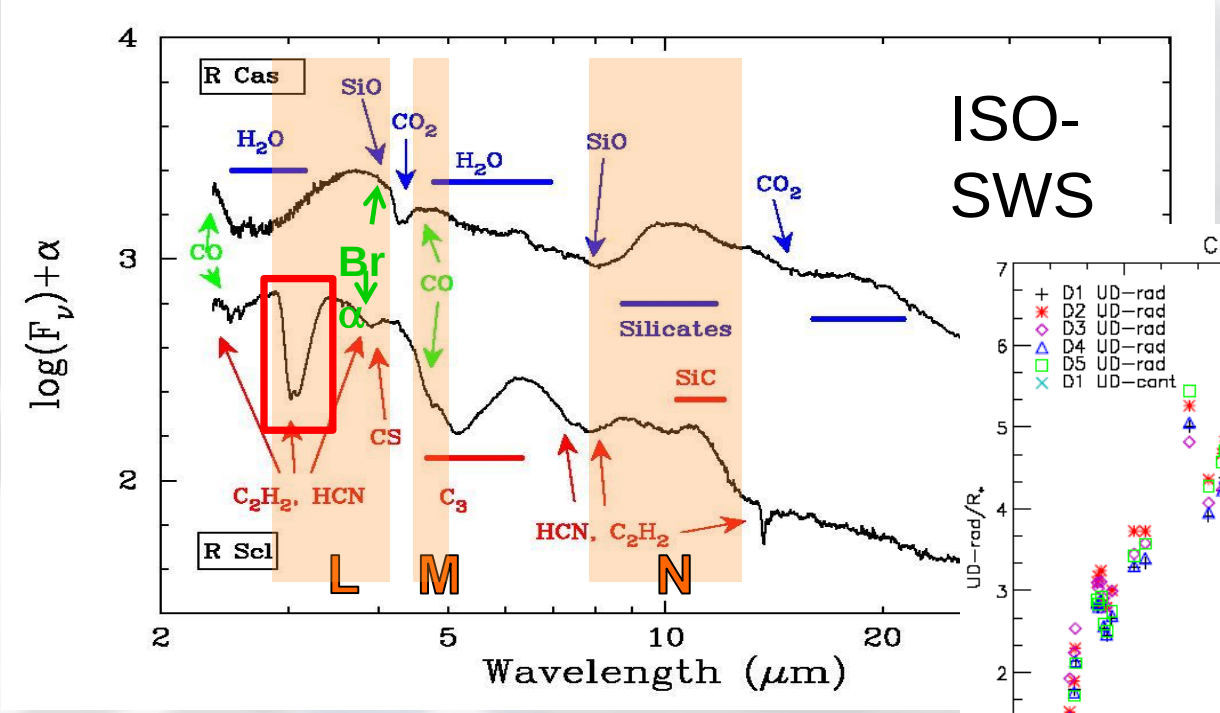
Carbon Stars



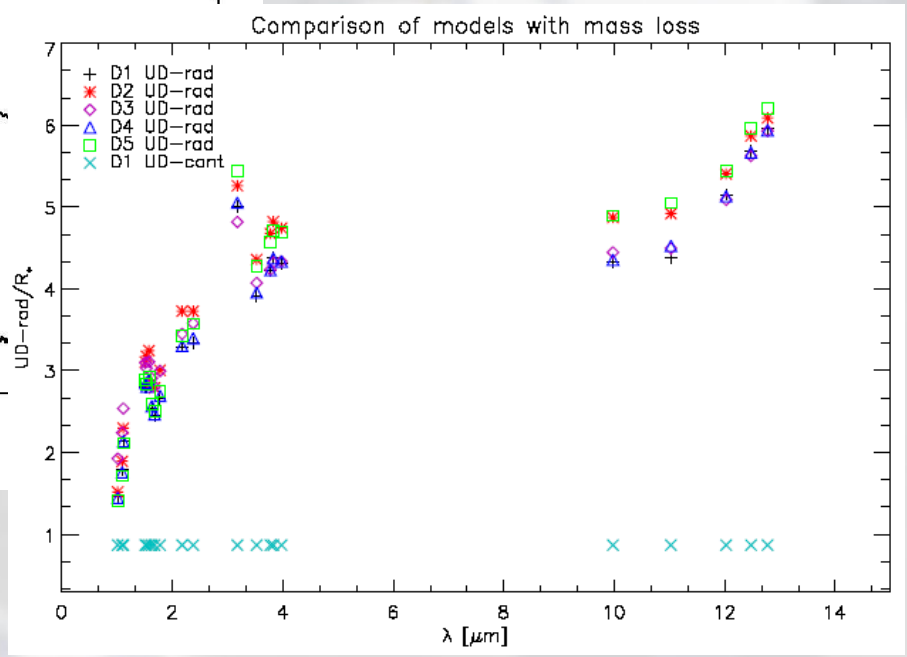


- thermally pulsing AGB stars with $M_{ZAMS} \geq 1.5 M_{\odot}$
- C/O>1 due to dredge-up of He-burning products
- C-rich molecules and dust dominate

Carbon Stars and MATISSE



ISO-SWS



Paladini+(2009)

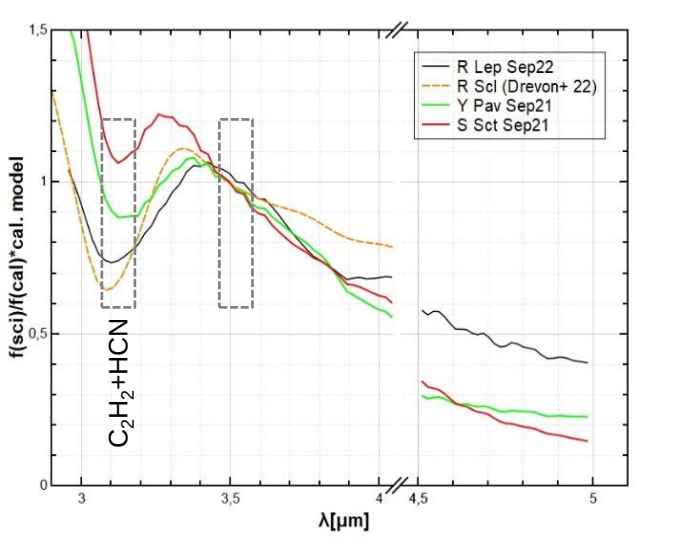
Motivation

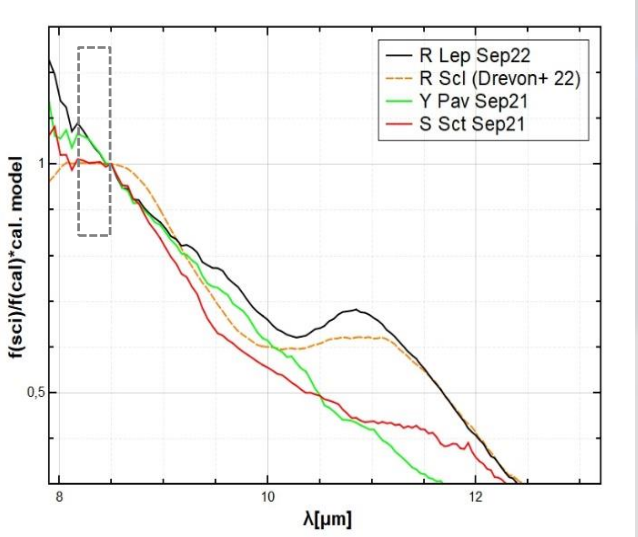
- C_2H_2 is building block of dust (amC, possibly SiC-dust)
- MATISSE can observe C_2H_2 and dust *simultaneously*
- compare with model predictions

Targets & Observations

Target	Type	P	ΔV	D[pc]*	dM_{-6}/dt	SiC	
S Sct	SR	148:	1	415	<0.1	n?	detached shell
Y Pav	SR	418:	<2	822	0.2	y?	
R Lep	M	430	5	446	0.7	y	
R Scl	SR	372	2.8	387	0.5	y?	detached shell
X TrA	Irr		1	353	1.5	y?	

- two LMN snapshot observations (low spectral resolution) for S Sct, Y Pav & R Lep, LMN imaging for R Scl (Drevon+, 2022) & X TrA.
- three narrow regions: 3.1µm (C_2H_2+HCN), 3.5µm ("contin."), 8µm (dust)





*Abia+ (2022)

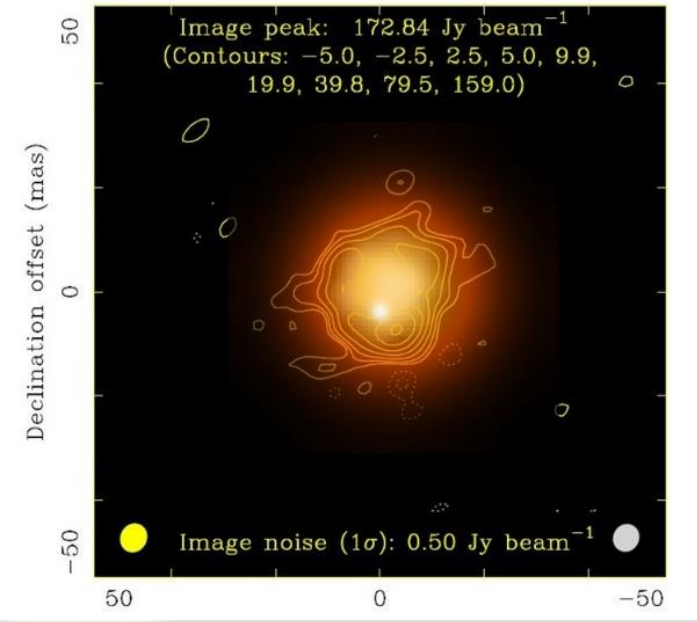
Summary of Observations

Target	∅NIR [mas]	∅MIDI FWHM	∅MATISSE FWHM			Closure Phase?			
		8μm	3.1μm	3.5μm	8μm	3.1μm	3.5μm	8μm	SiC
S Sct	6	12	5	4	6	✓	×	×	–
Y Pav		5	6	5	7	✓	×	×	–
R Lep	12	12+29	26+BG	15+3	17+50	✓	(✓)	×	✓
R Scl	11	25	11	7	11	✓	(✓)	×	✓

Size estimates for model comparison:

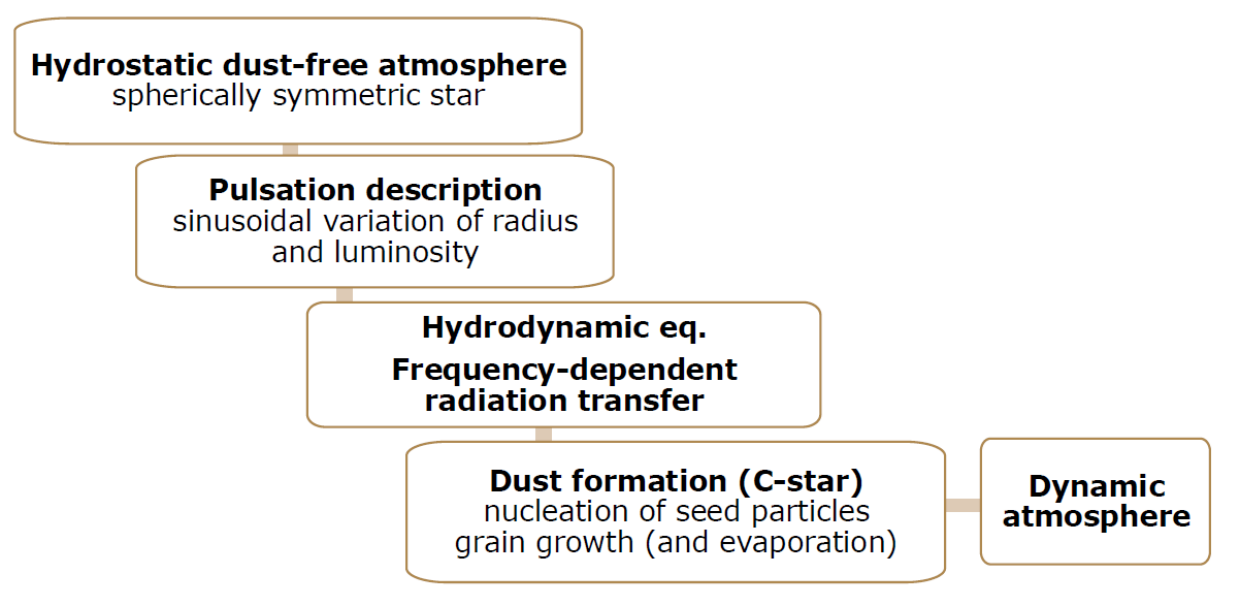
a) fit of single Gaussian to visibility V

b) scaling the spatial frequency for best V-match of two regions → R(3.1)/R(3.5) and R(8)/R(3.5)

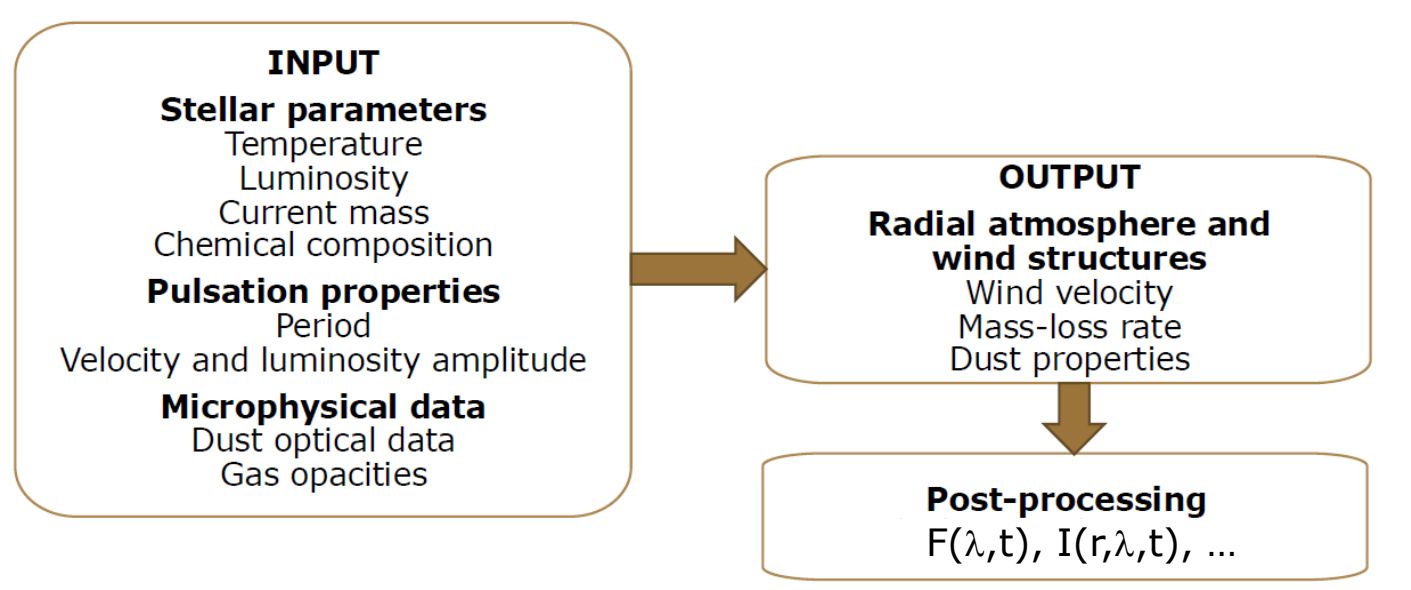


"best" fit 3.1μm LITpro model superposed on ALMA HCN maser image by Asaki+(2023)

DARWIN 1D RHD-Models

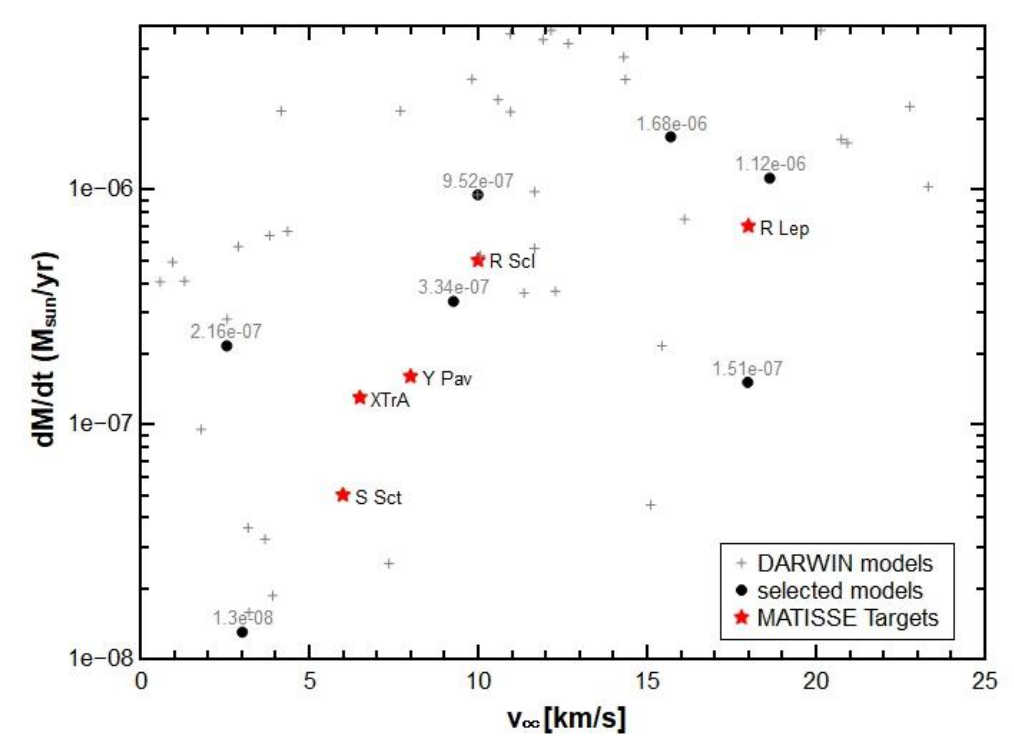


Siderud
(2023, Lic.Thesis)



DARWIN Models

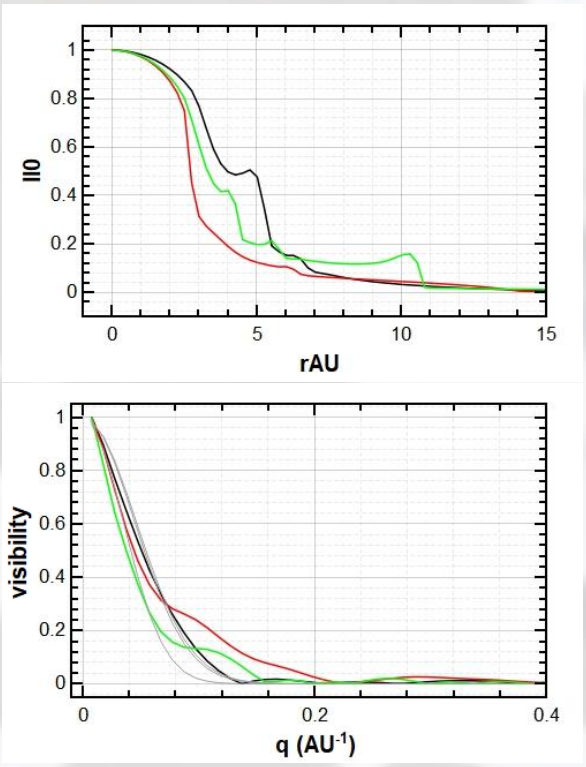
- Selected seven models spanning the mass loss and wind velocity v_∞ of the targets (no specific fits attempted)



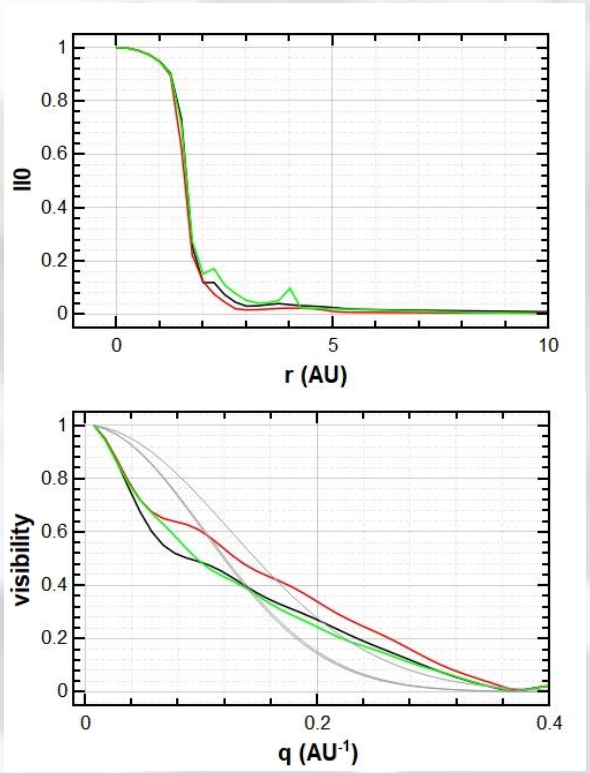
Eriksson+ (2022)

- three maxima and minima for each model
- intensity and visibility profiles around 3.1, 3.5 & 8μm
- size estimates by fitting a Gaussian to Visibility(q)

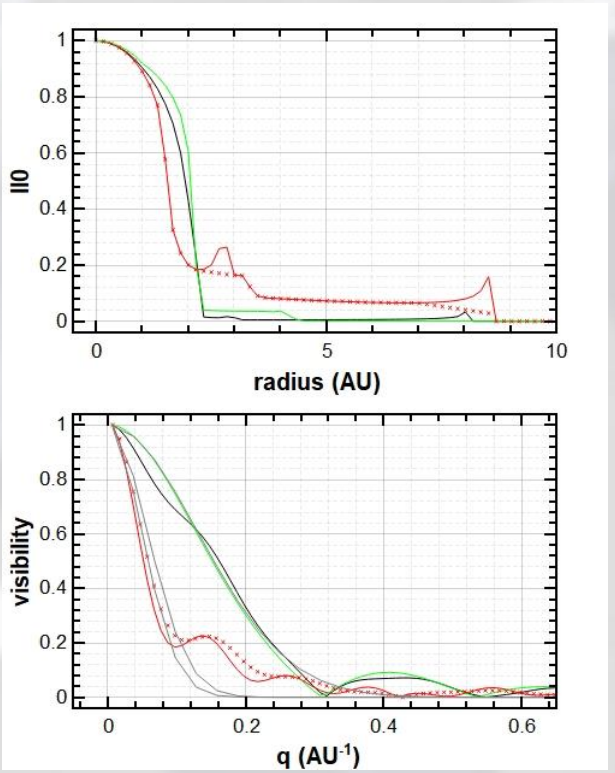
Example Model Profiles



Minima 3.1µm, MLR 10^{-6}



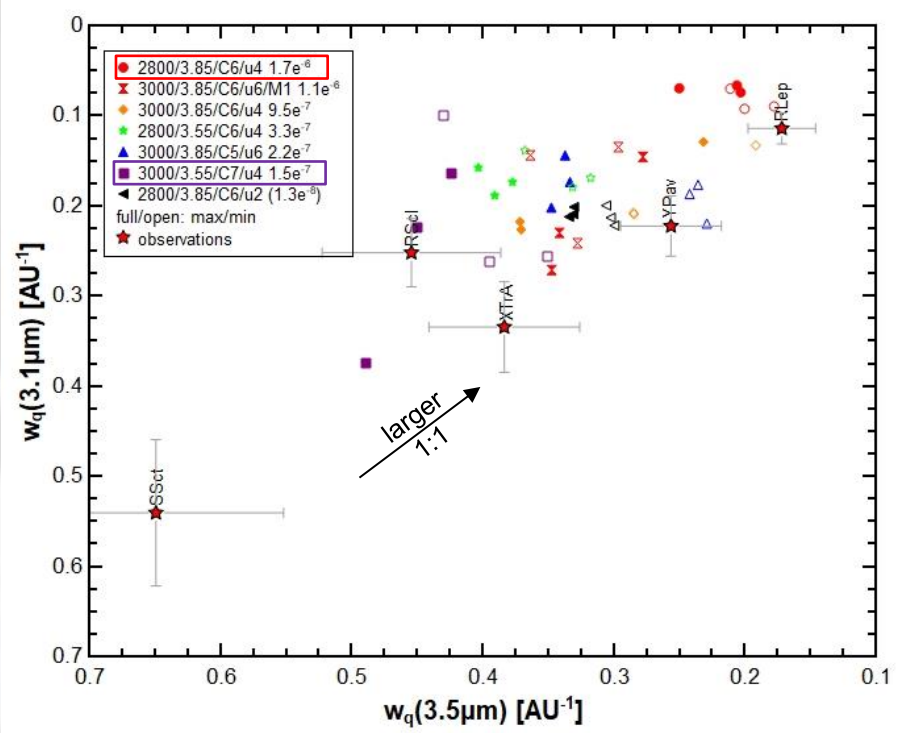
Maxima 3.5µm, MLR 10^{-6}

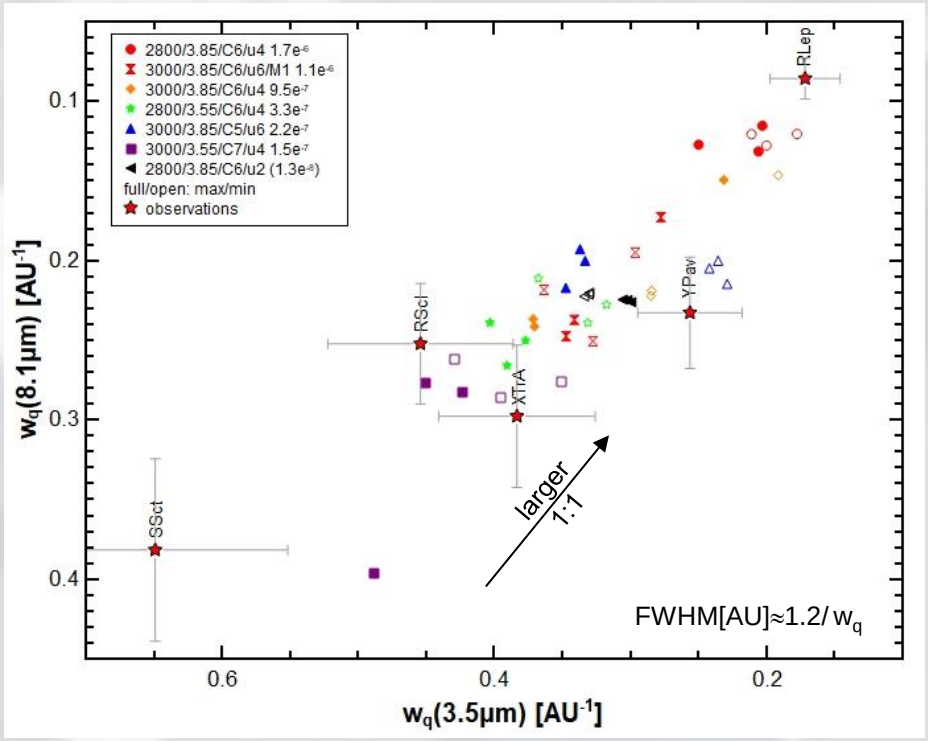


Minima 3.1µm, MLR 10^{-7}

- dust+gas shells cause extended wings/bumps/wiggles in 1st lobe
- large cycle-to-cycle differences possible ($P_{dust\ formation} \neq P_{pulsation}$)
- Gaussian not the best size estimate but simple

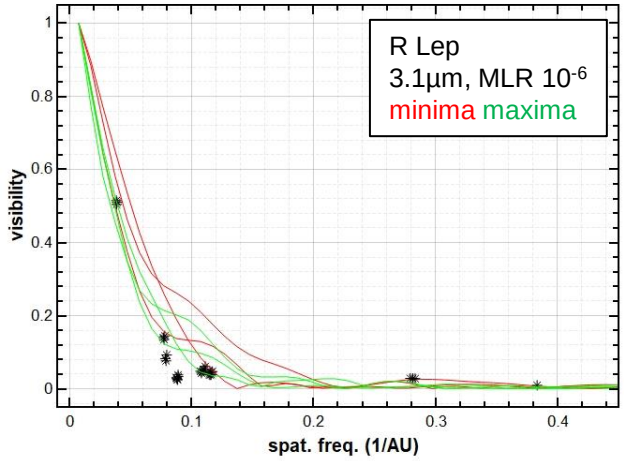
Observations ⇔ Models: Sizes

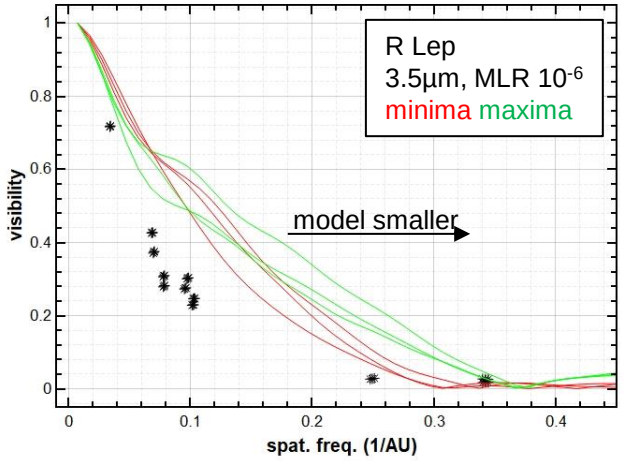


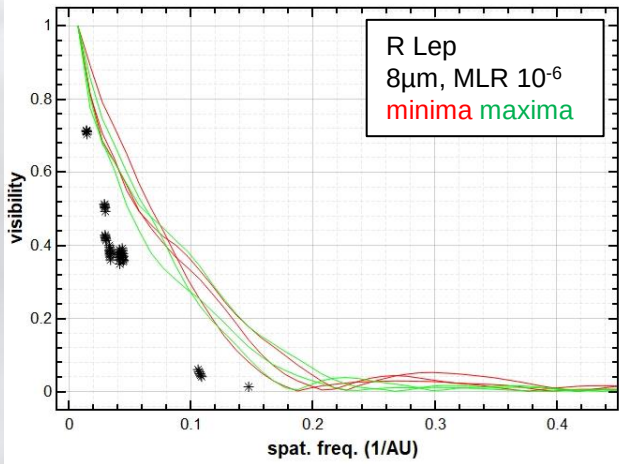


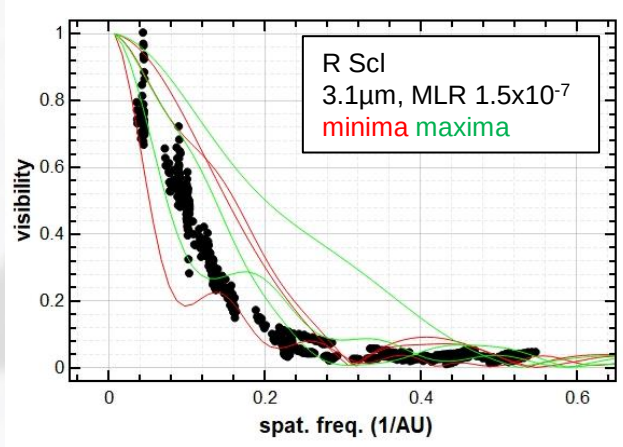
- models and observations cover comparable range
- (observed) sizes roughly increase with amplitude/MLR
- similar trend for models but notable scatter (cycle-to-cyle differences, model parameter-dependency)
- ∅(3.1μm) ≈ ∅(8μm) > ∅(3.5μm)
- S Sct too small in L (hydrostatic?)

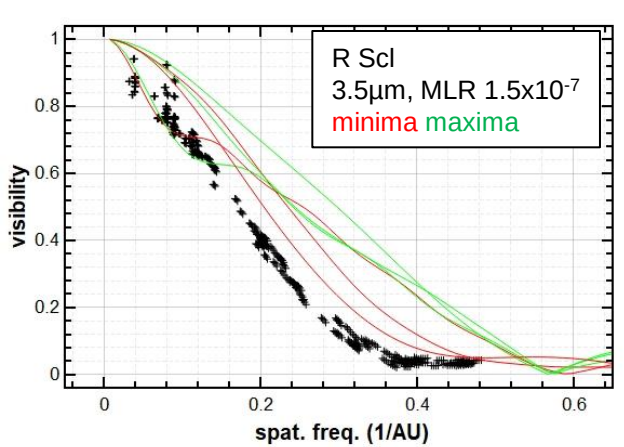
Observations ⇔ Models: Visibilities

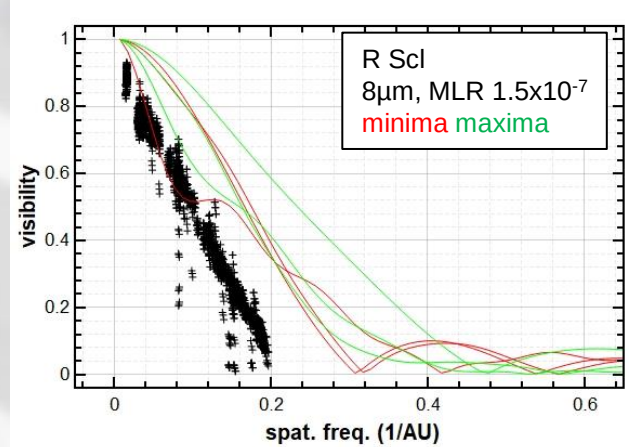












- selected models too small in general?
- deviations from 1D-symmetry in real stars: increase scatter in observed profiles & observations may be a superposition of many model phases

→ 1D models can provide only likely range of stellar parameters

Conclusions

- all stars show asymmetries at 3.1µm
- asymmetries at longer wavelengths only for large amplitude variables
- comparable sizes at 3.1µm and at 8µm
- R Lep L-band size consistent with HCN maser extent
- reasonable overlap of models and observations but
  - a larger set of models needs to be analyzed (trends with C/O, T, M,…)
  - more observations/imaging for C-rich Miras needed (R Lep!)
  - deviations from 1D have to be kept in mind