How M-type AGB stars bite the dust

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Part of the ERC project STARKEY (PI Paola Marigo)

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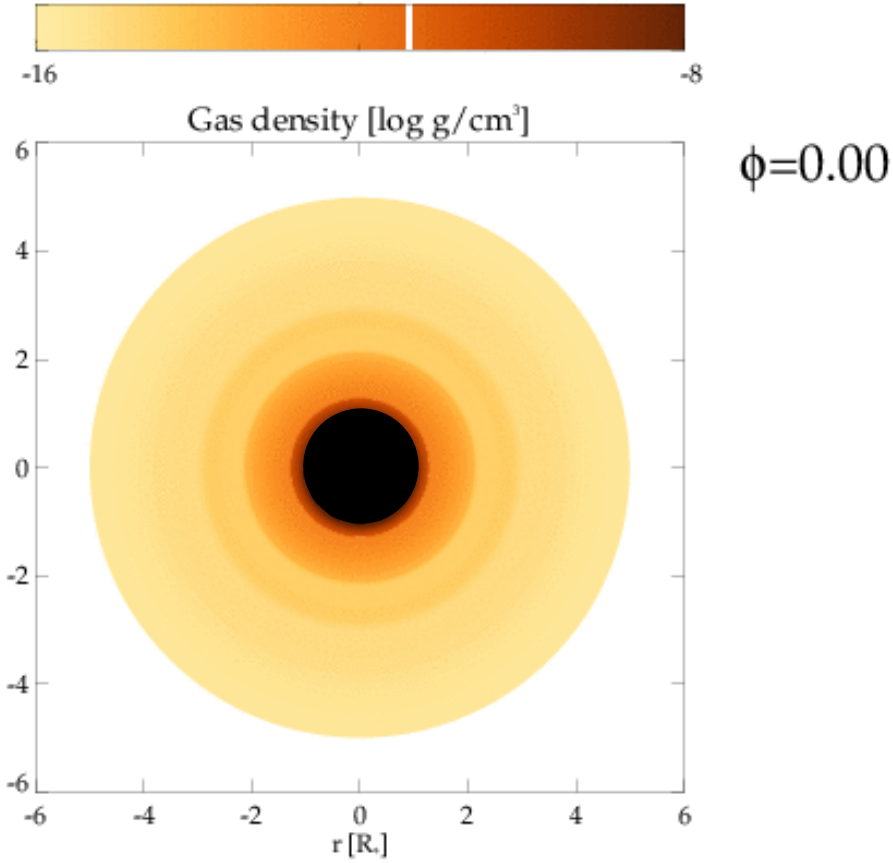
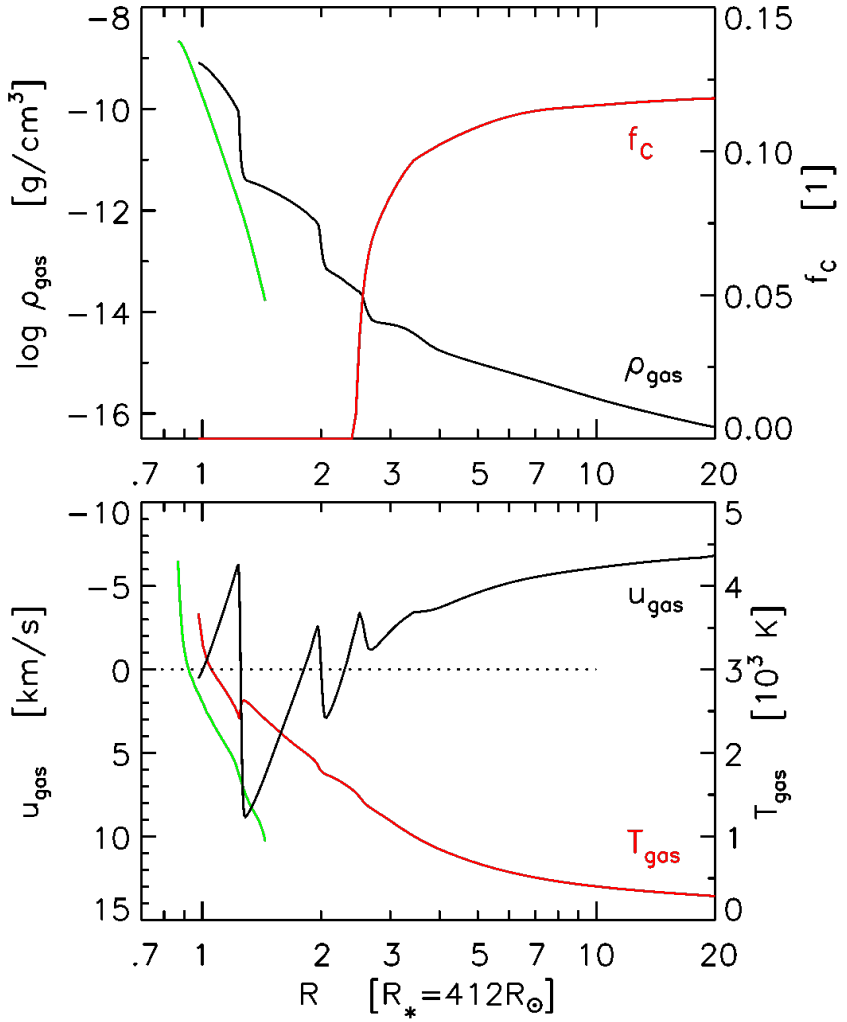
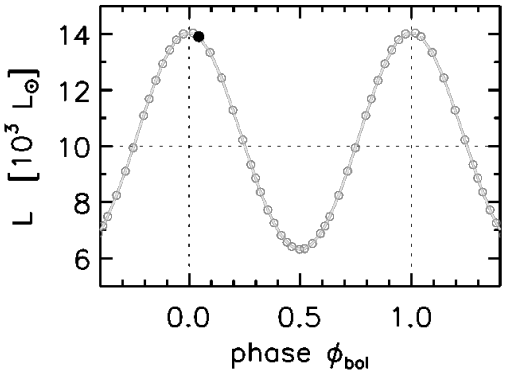
Time-dependent wind models (Höfner et al. 2003, Höfner 2008)

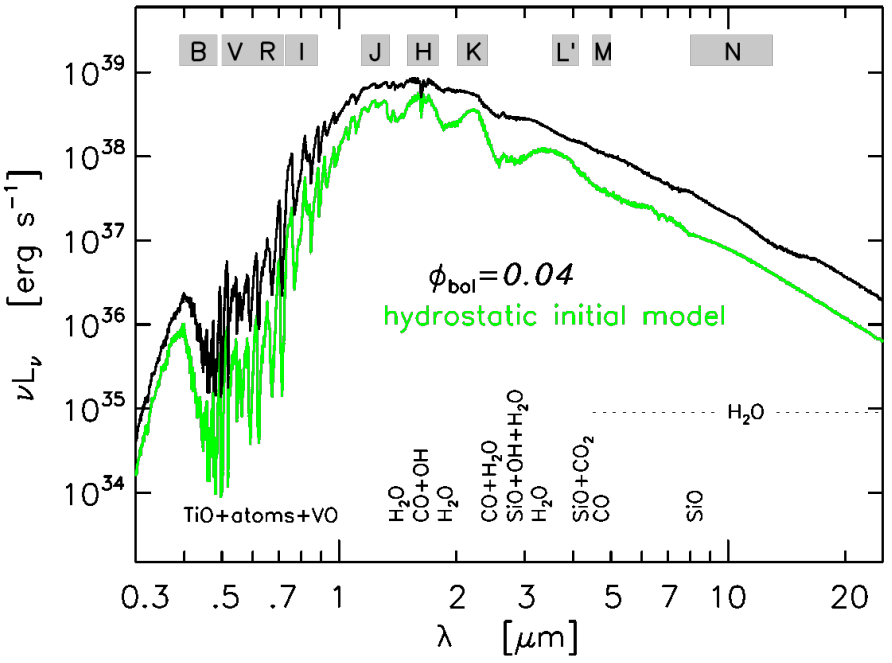
- The pulsations are simulated by sinusoidal variations at the inner boundary
- The variable structure (pulsations, shocks, winds) is determined by solving the hydrodynamic equations.
- Time-dependent growth of Mg_2SiO_4 grains, starting from seed particles.
- Grain-size dependent dust opacities, taking into account both absorption and scattering in the radiative acceleration.
- Frequency-dependent opacities for dust and gas.



The stellar wind is driven by photon scattering on "big" Mg_2SiO_4 grains!!

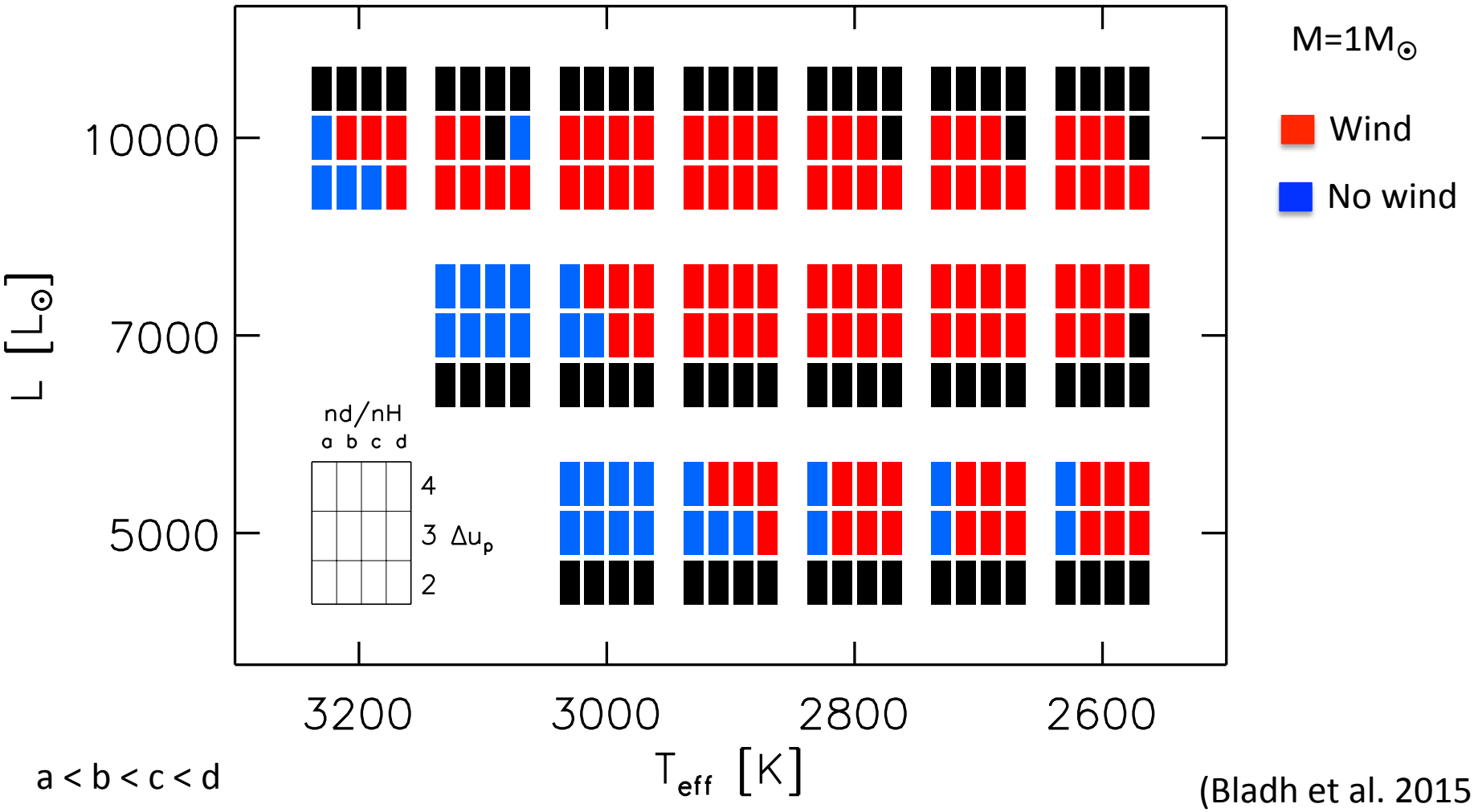






(Model C1 from Bladh et al 2013, image by W. Nowotny)

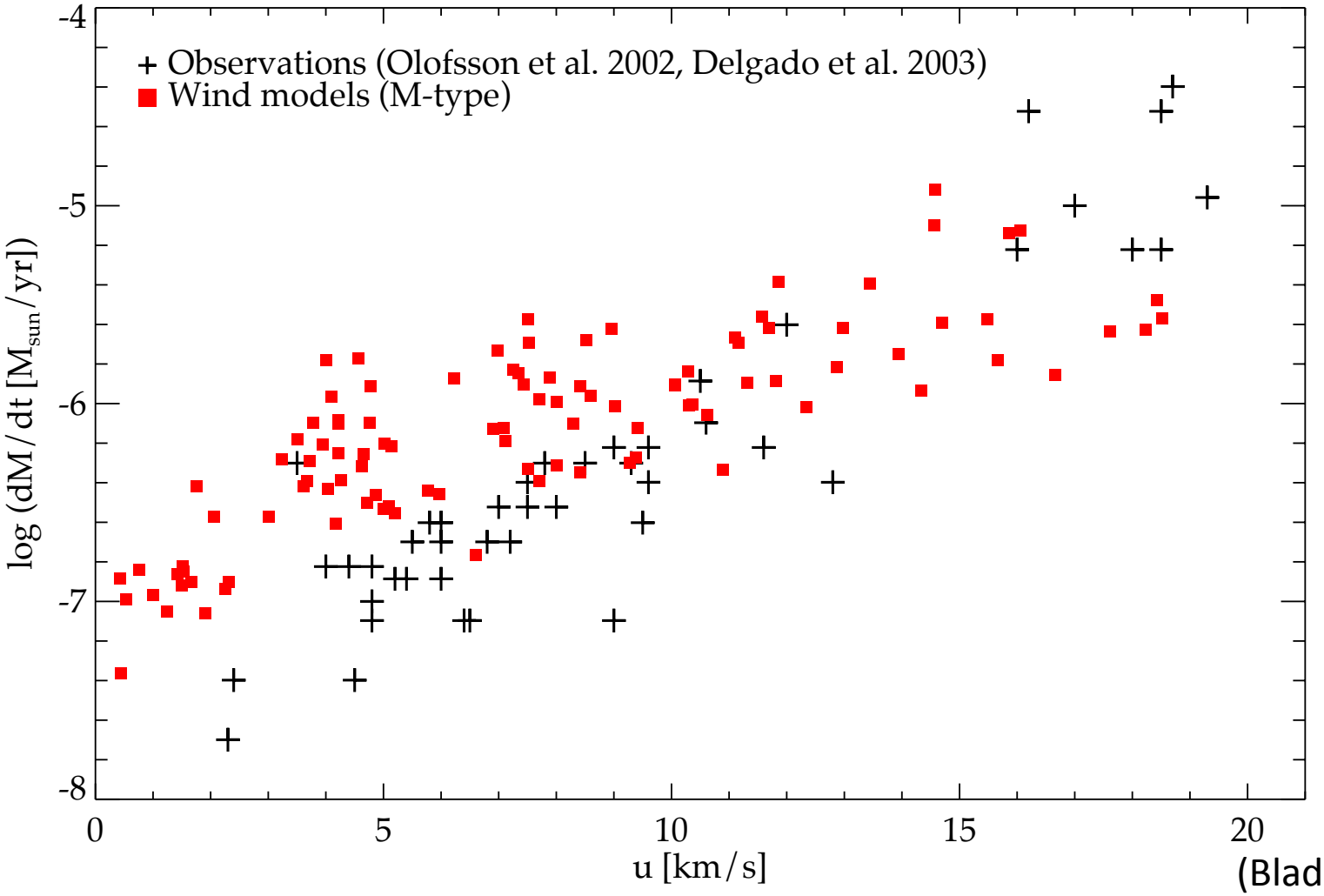
Wind models of M-type AGB stars



a < b < c < d

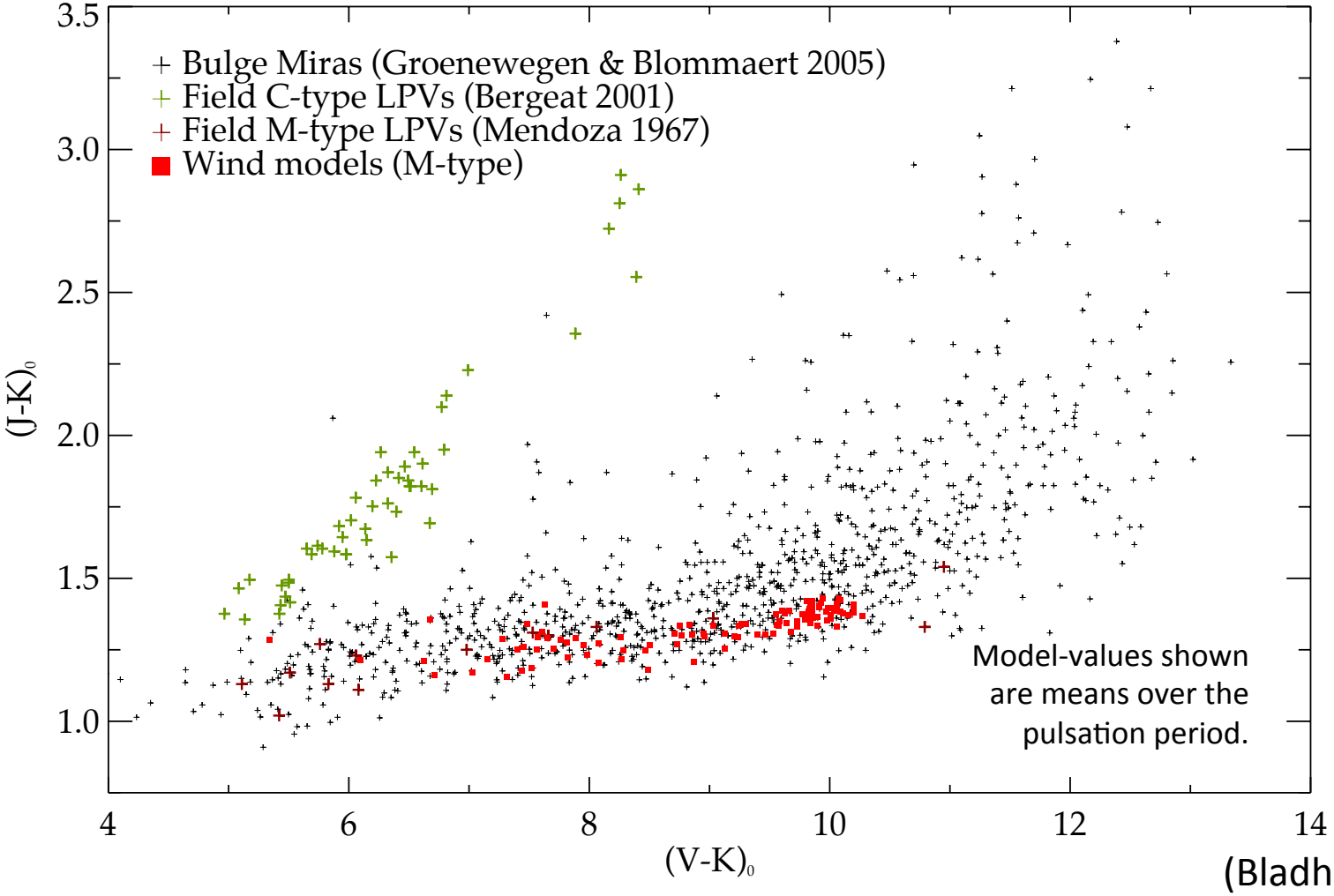
(Bladh et al. 2015)

Dynamical properties



(Bladh et al. 2015)

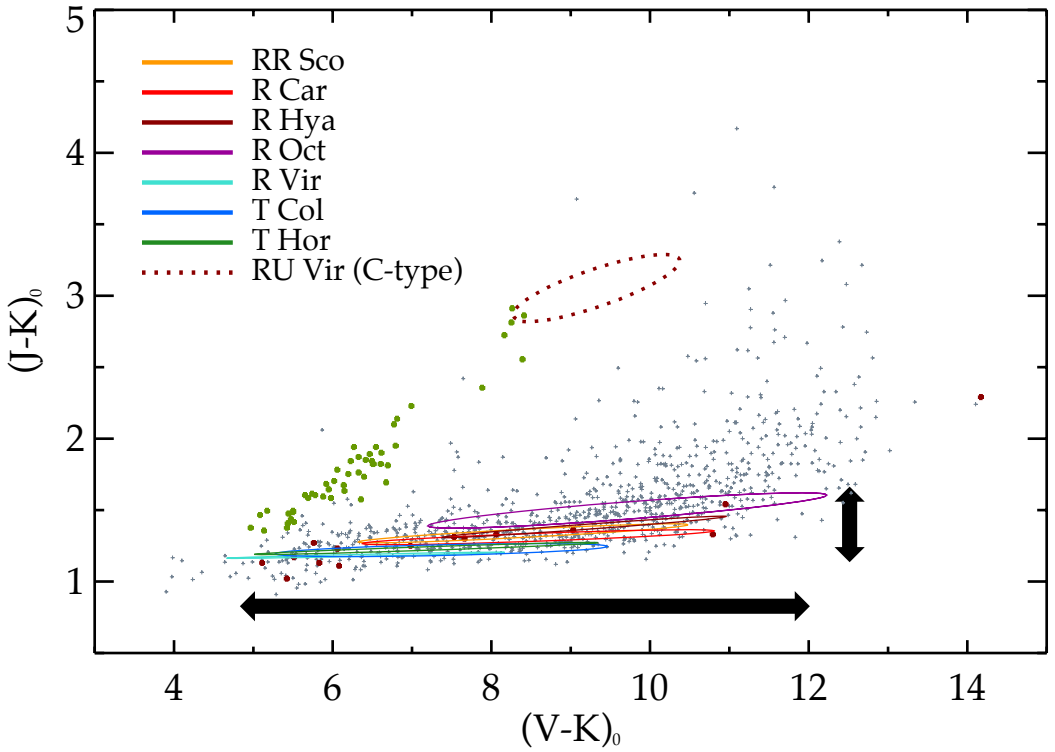
Photometric properties in near-IR



(Bladh et al. 2015)

The photometric variations are characterised by:

- large variations in (V-K)
- small variations in (J-K)



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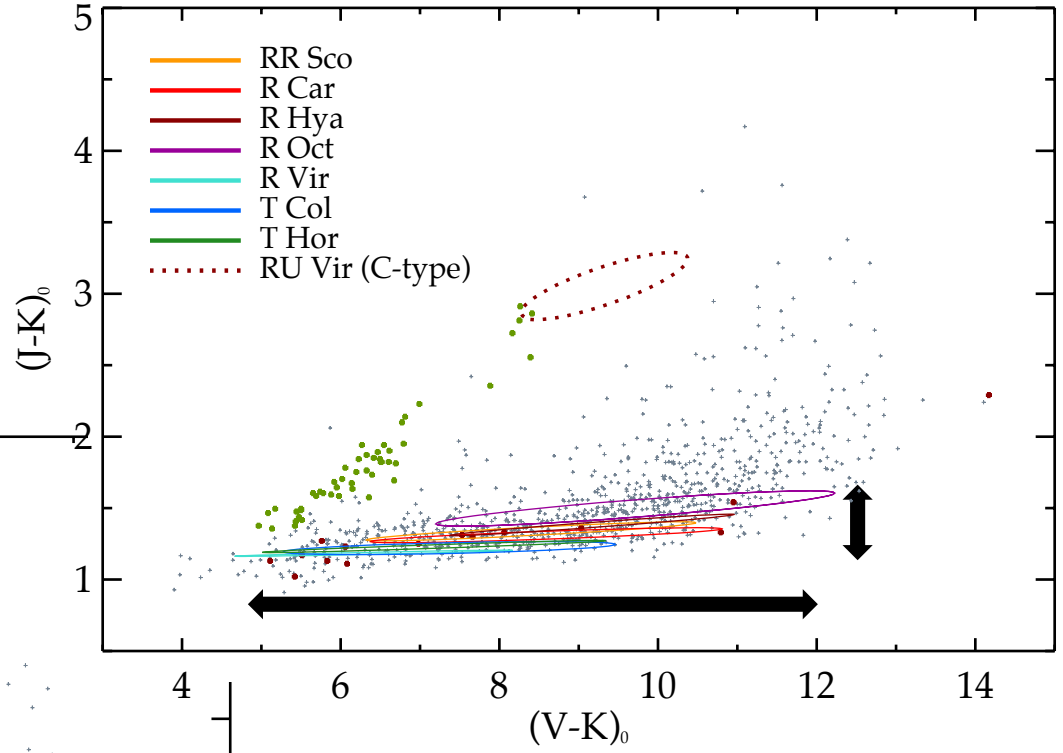
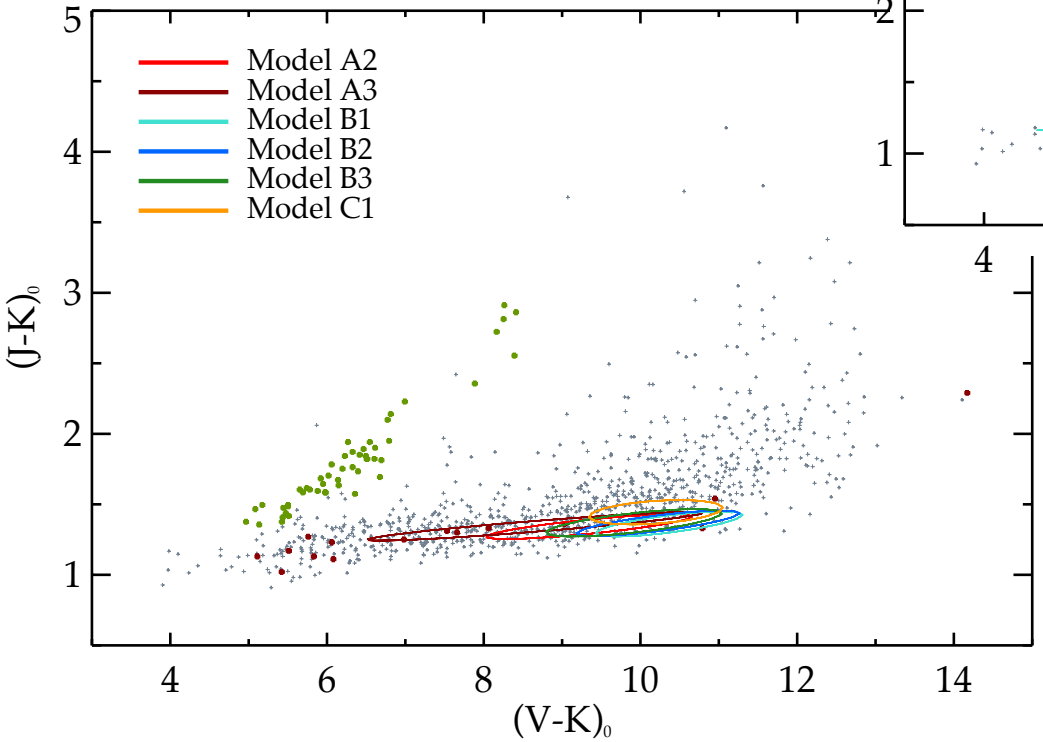
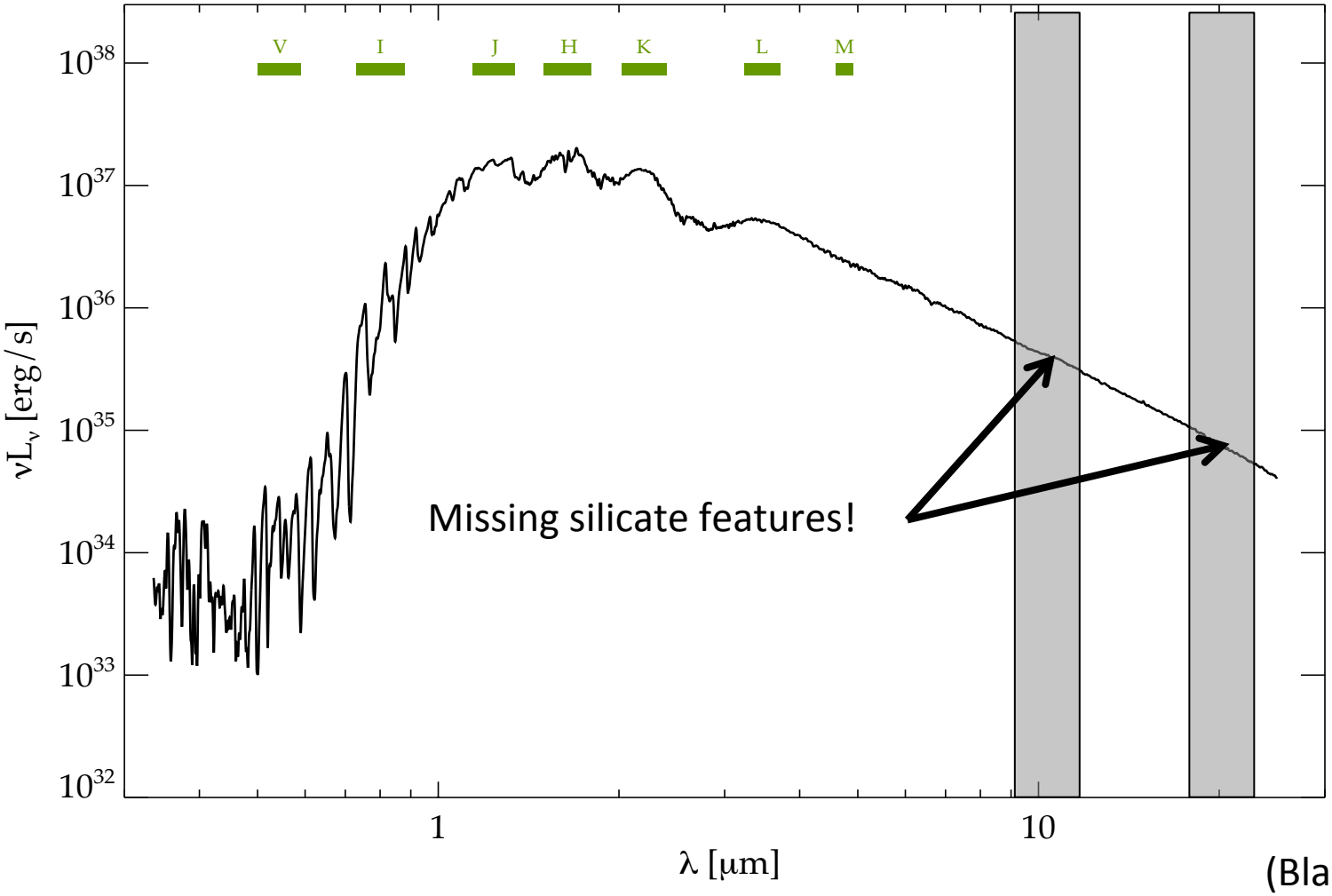




The variations in (V-K) are due to molecular changes during the pulsation cycle, not changes in the dust

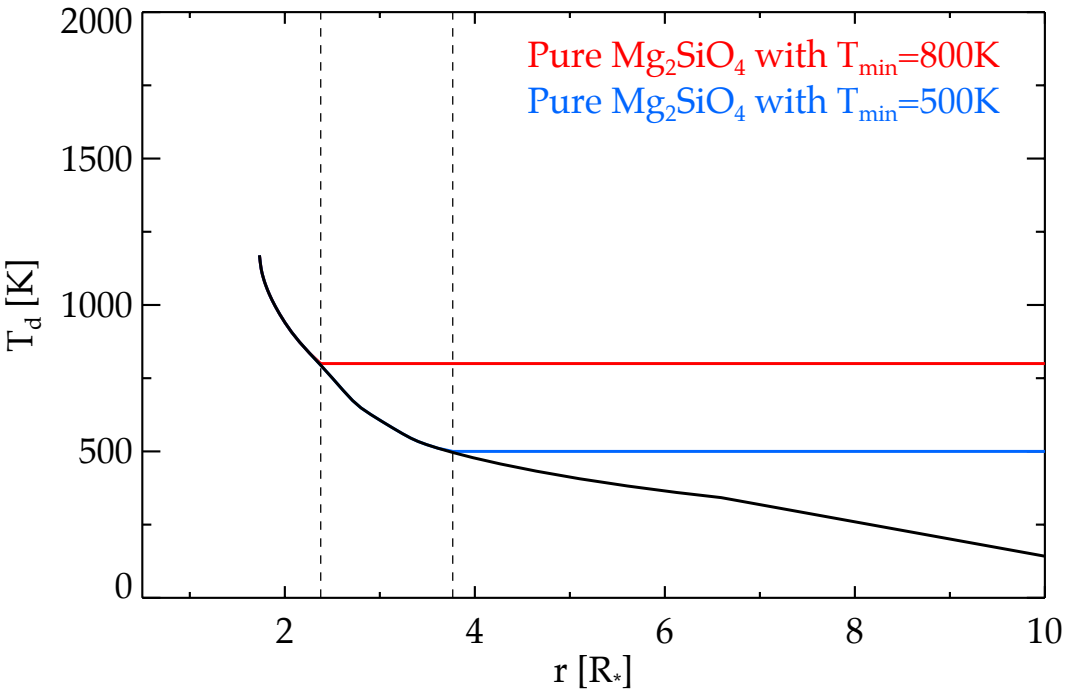
(Bladh et al. 2013)

Spectra in the mid-IR



(Bladh et al. 2013)

Keeping the grain temperature constant from ~3R_* outwards shows that the missing features are not due to low abundance of silicates, but too cool grains.



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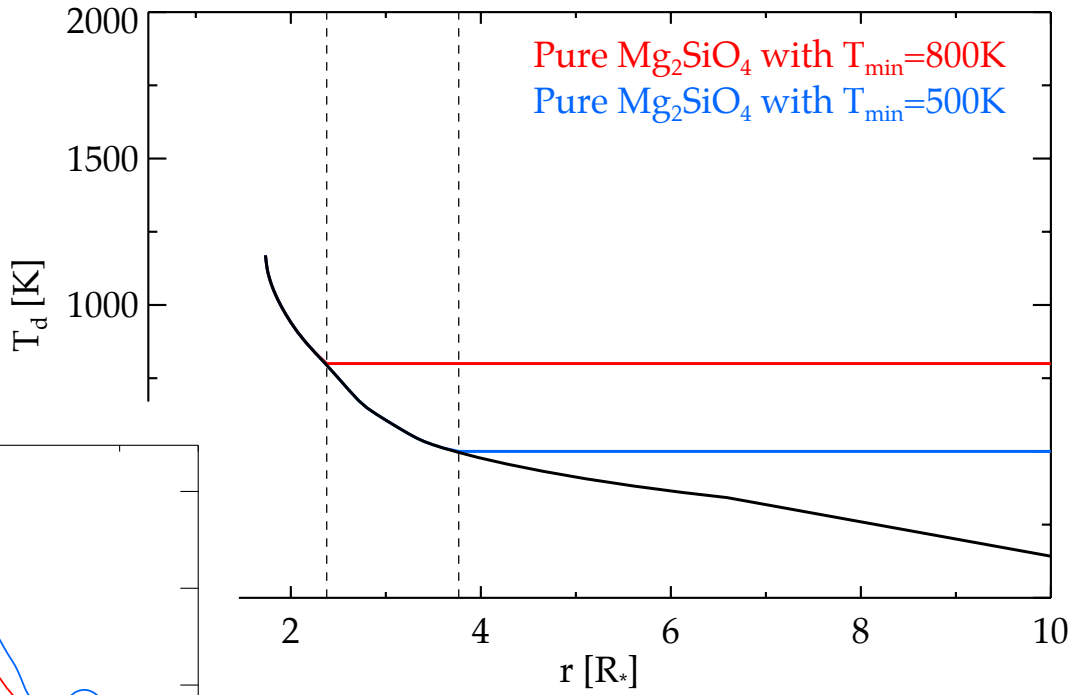
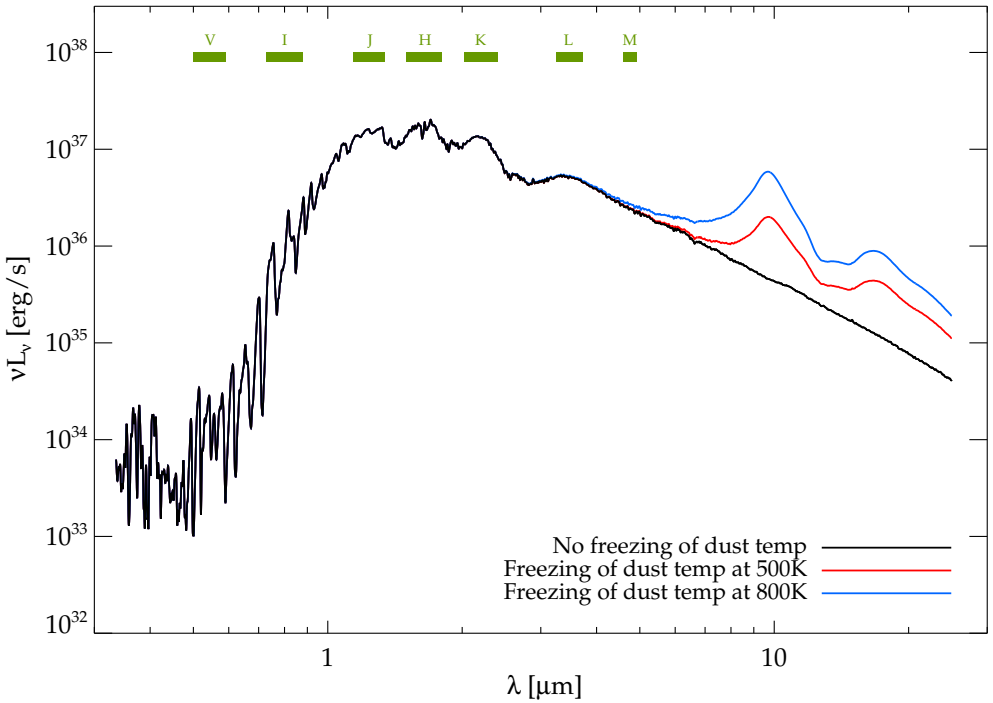
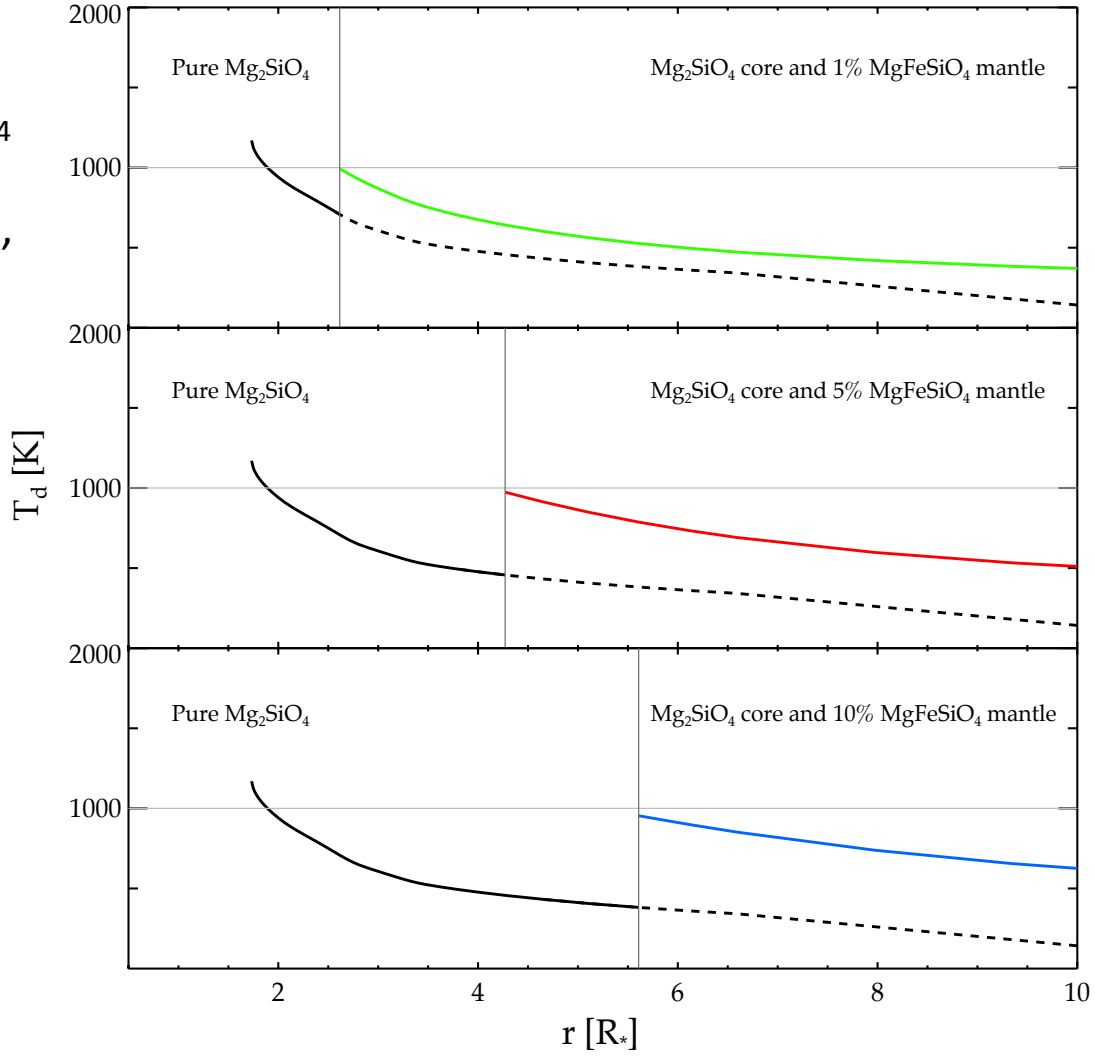




(Bladh et al. 2015)

Adding a thin mantel of $MgFeSiO_4$ when this material is thermally stable will also heat up the grains, resulting in silicate features.



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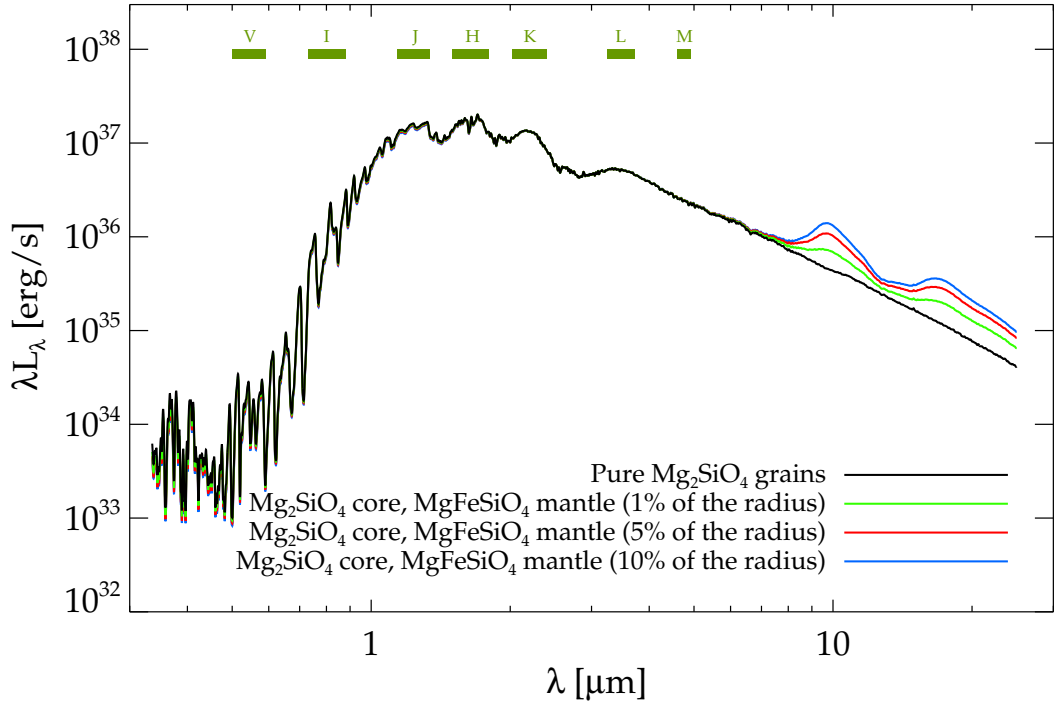
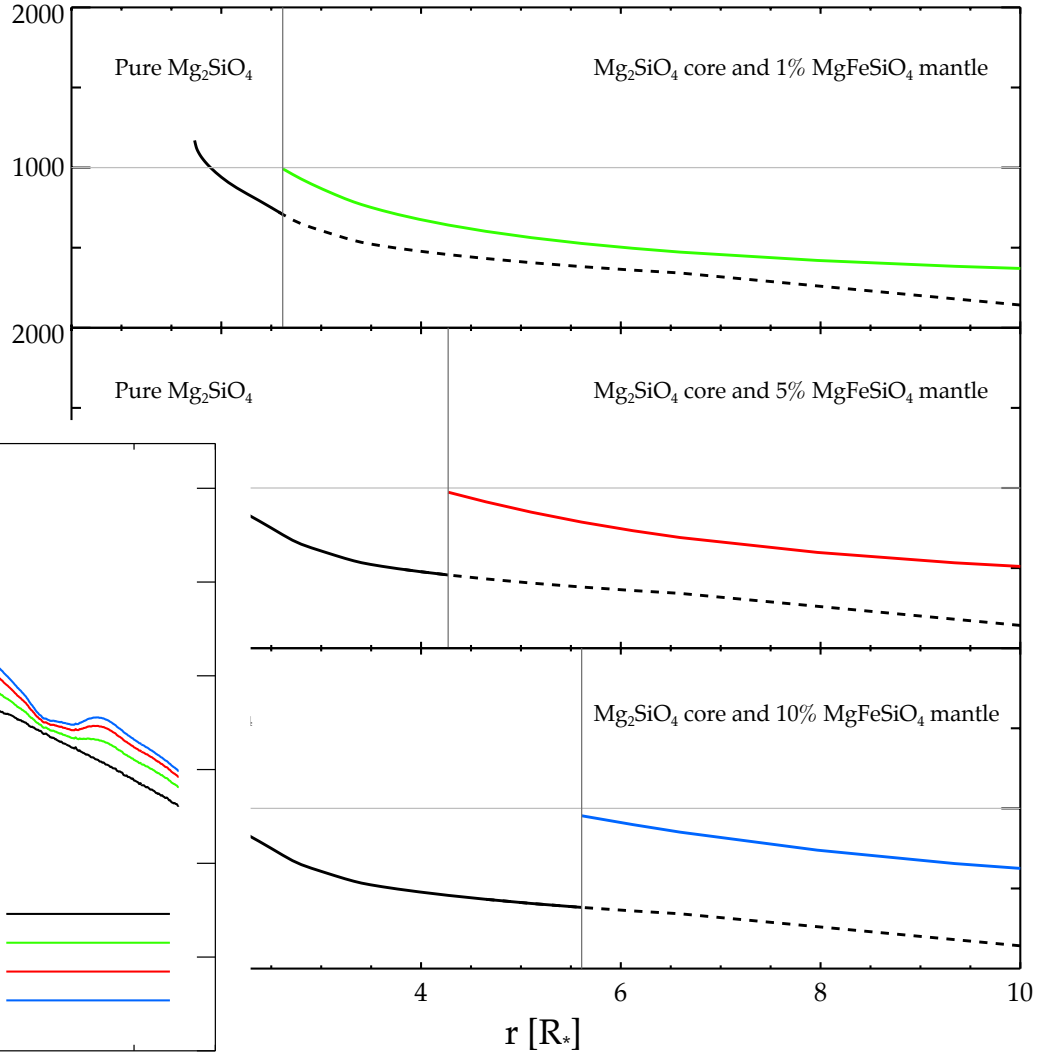
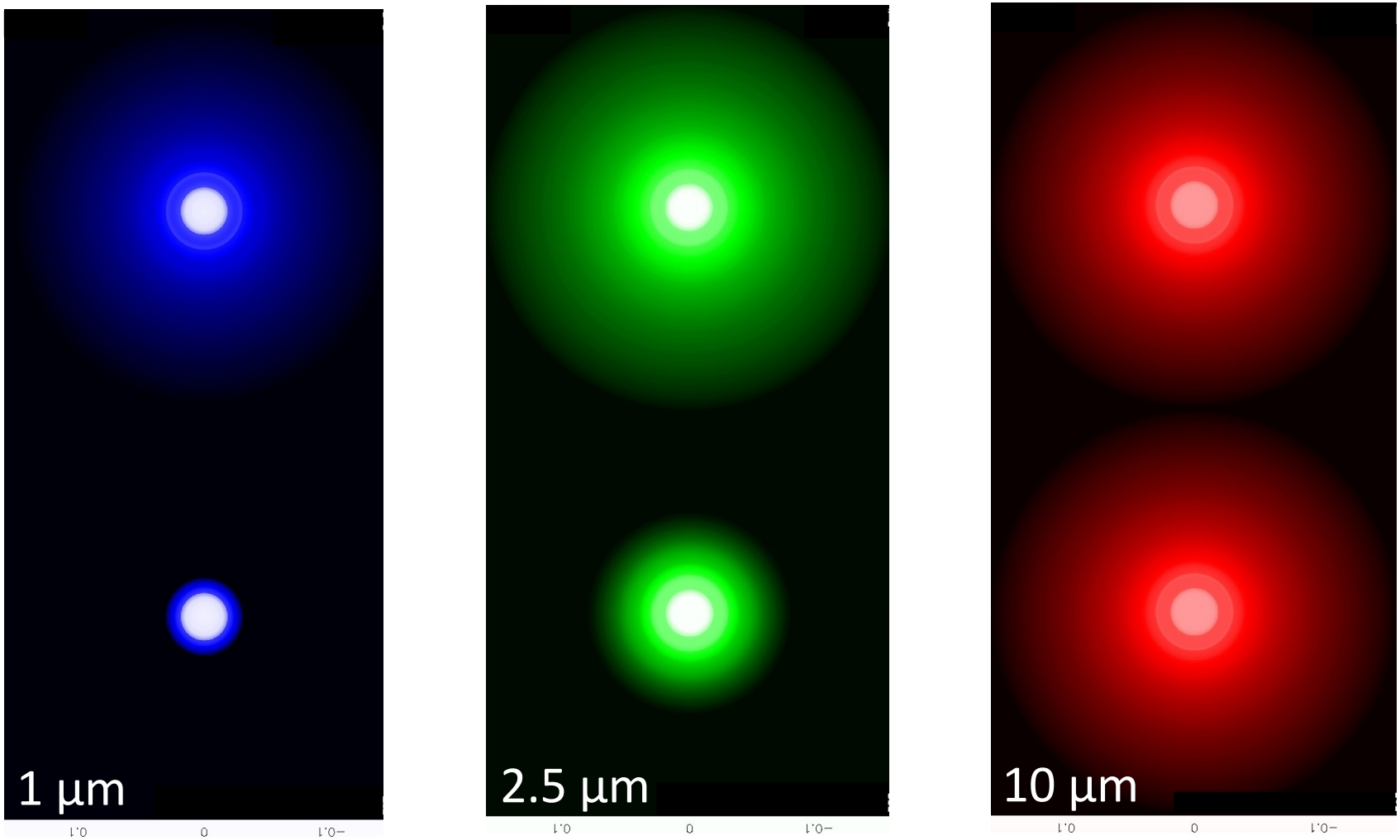




(Bladh et al. 2015)

Intensity profiles including scattering



(Image from B. Aringer)

Intensity profiles without scattering

Summary

- We present the first extensive set of set of time-dependent wind models for M-type AGB stars.

- These wind models reproduce well both observed dynamic properties and photometry, especially the large photometric variation in the visual band during a pulsation cycle.

- The current wind models of M-type AGB stars (with pure Mg-silicate grains) do not reproduce the characteristic silicate features. “Dirty” grains may solve this problem.

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