Mining the PTI-archive: uncovering the pulsating photospheres of Miras
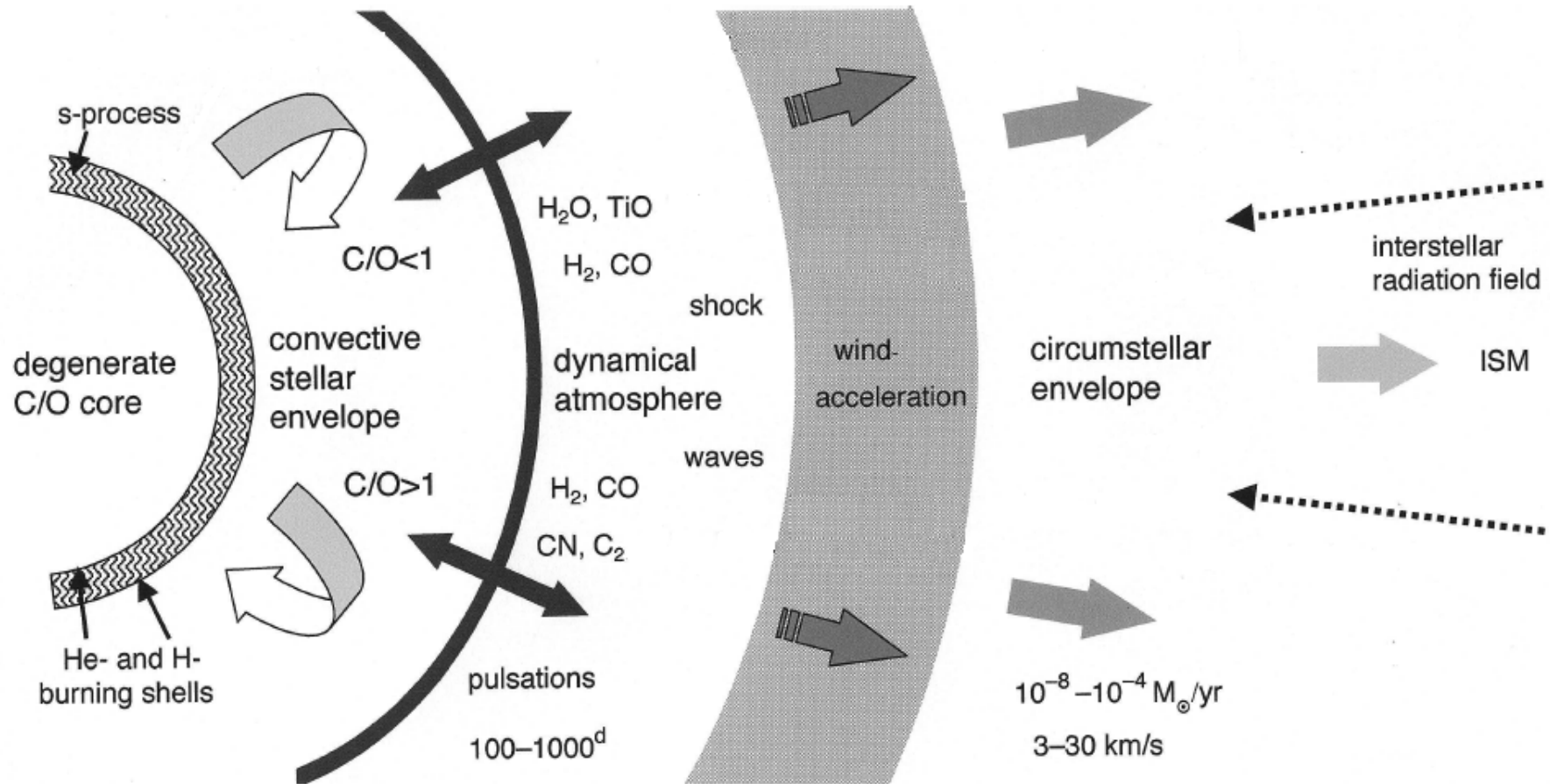
by Michel Hillen

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Promotor: prof. Dr. Hans Van Winckel
Co-promotor: Dr. Tijl Verhoelst
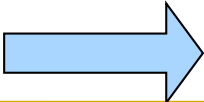Co-I: Dr: Bram Acke

Pulsations in AGB-stars?

Interferometry and the AGB

- Aim: "directly observe/probe the interplay between pulsating photosphere and levitated atmosphere as a function of time"
  - Snapshots
    - Le Bouquin (2009)
    - Ohnaka (2005)
    - Perrin (2004)
  - Several snapshots
    - Lacour (2009)
    - Ohnaka (2007)
  - Time-resolved
    - Woodruff (2008) (Keck Aperture Masking Experiment)
    - Thompson(2002) (S Lac and RZ Peg with PTI)

Mining the PTI archive

- Palomar Testbed Interferometer (dual-star architecture,B ~110m) (Colavita 1999)

- Goals: diff. astrometry in search of planets + technology demonstrator for Keck and SIM

- > 50 publications (YSO's, binary orbits, PHASES, oblateness of Altair,...)

- 99 Miras observed between 1999 and 2006

- > 5000 spectrally dispersed (5 channels) observations in K + 150 in H (4 channels)

⟹ **pilot study of R Boo** (M3e-M8e,P=223d,d=750 pc)
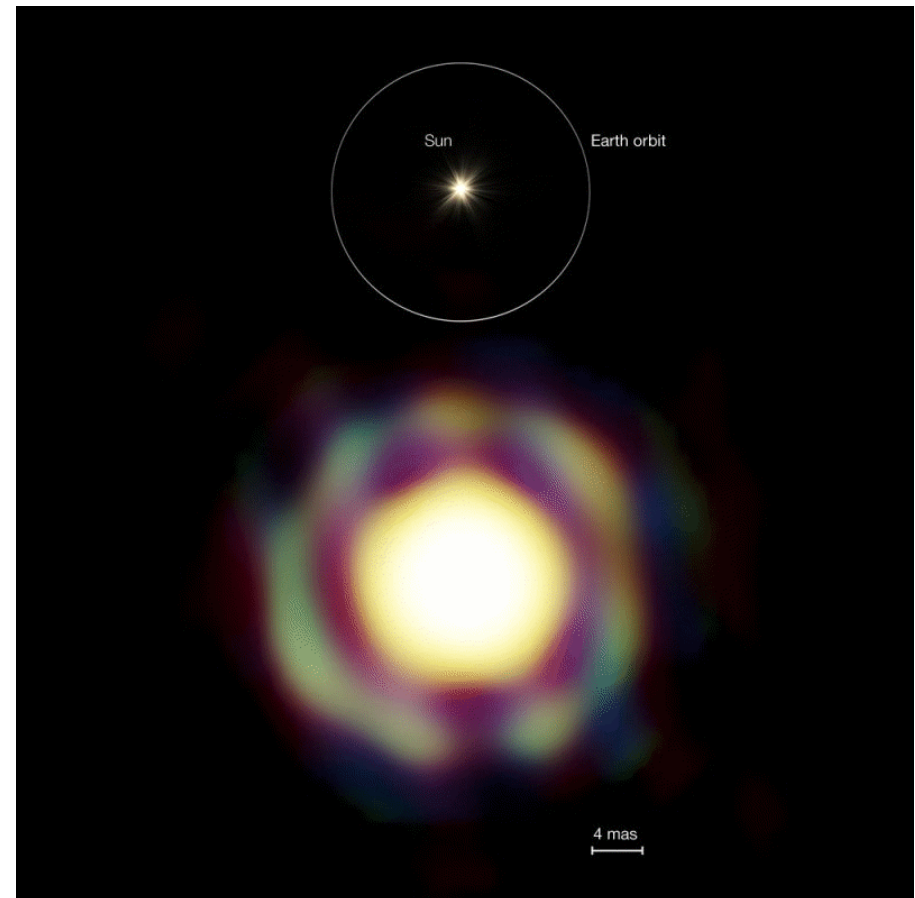
A simple model: UD(t,λ)~sin(t,λ)
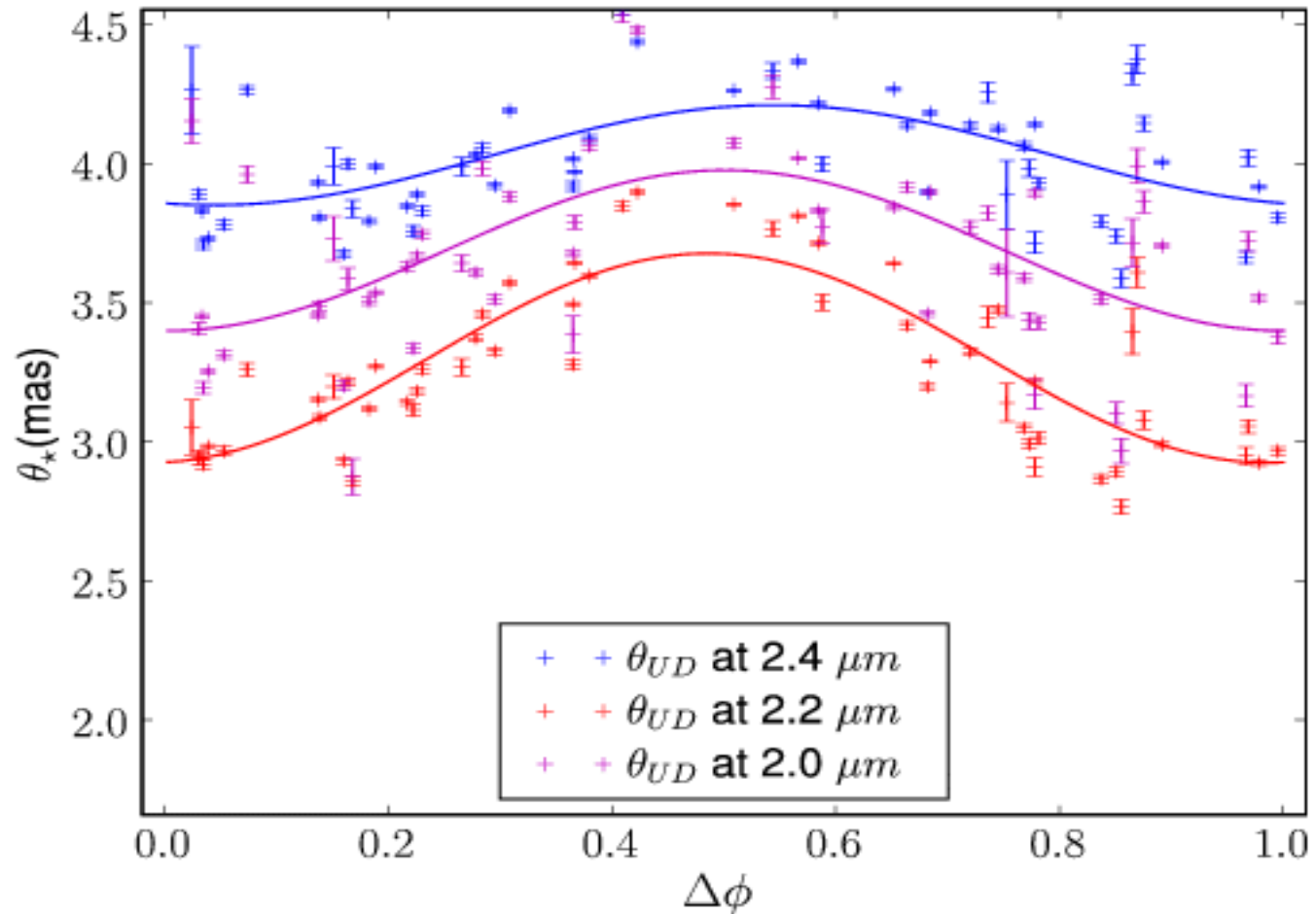
In agreement with Thompson (2002)

The molecular layer (molsphere) model

- Tsuji (1987)

- Mennesson et al. (2002)

- Perrin et al. (2004)

- Le Bouquin et al. (2009)

Remark: Not fully consistent physical representation of the object, but conversion of observations to image.
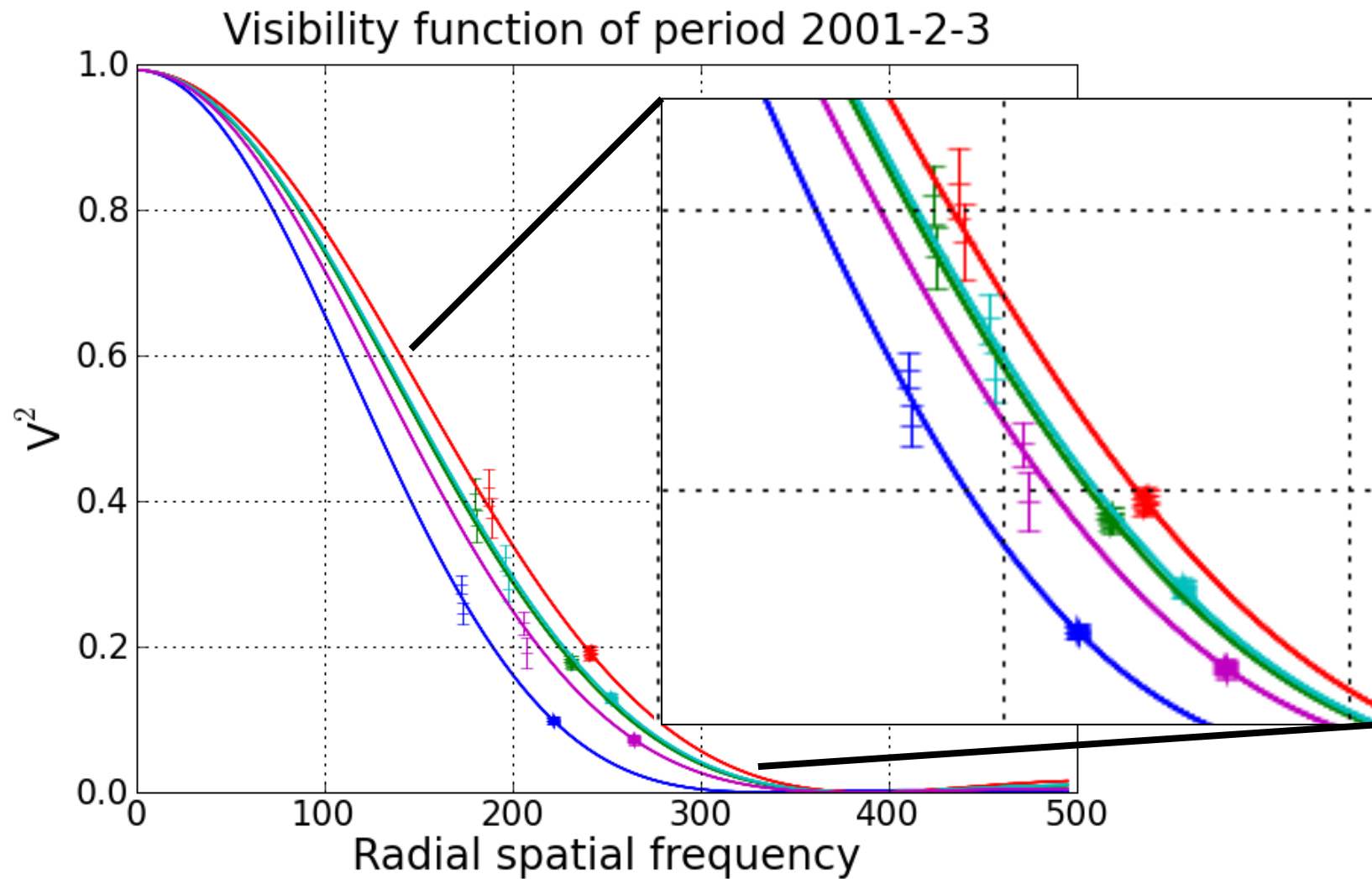
The model fitting

- 1D intensity profile

  ➡️ Hankel transform

- Time-dependent ~sine

- Complementary SAAO J,H,K photometry Whitelock et al. (2000)

- Nelder-Mead simplex algorithm

- Monte Carlo: starting values + errors

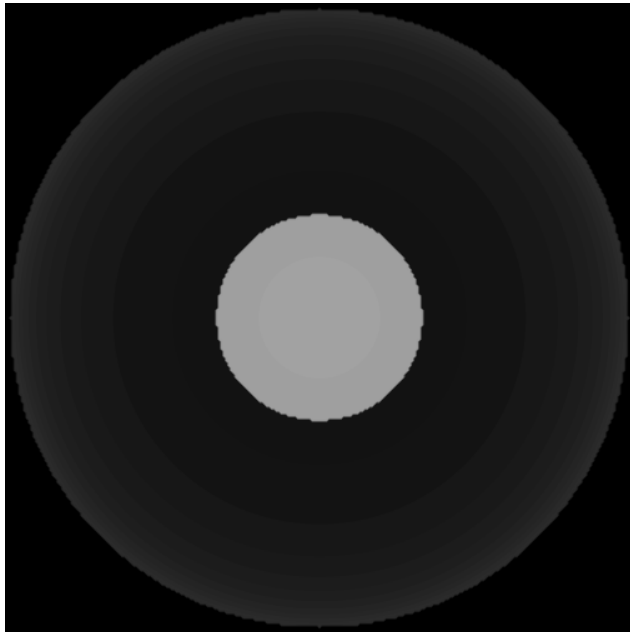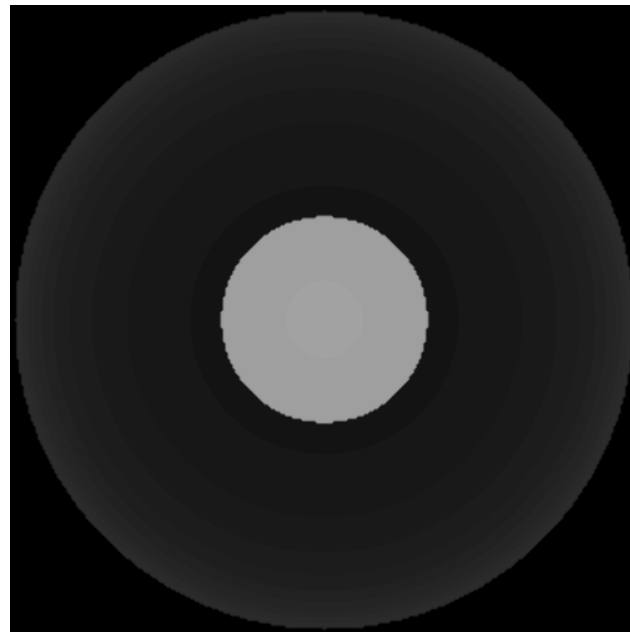- Correlation plots + simulations

layer

T_{layer}
$\varnothing_{layer}$
τ

T_*
$\varnothing_*$

θ

photosphere
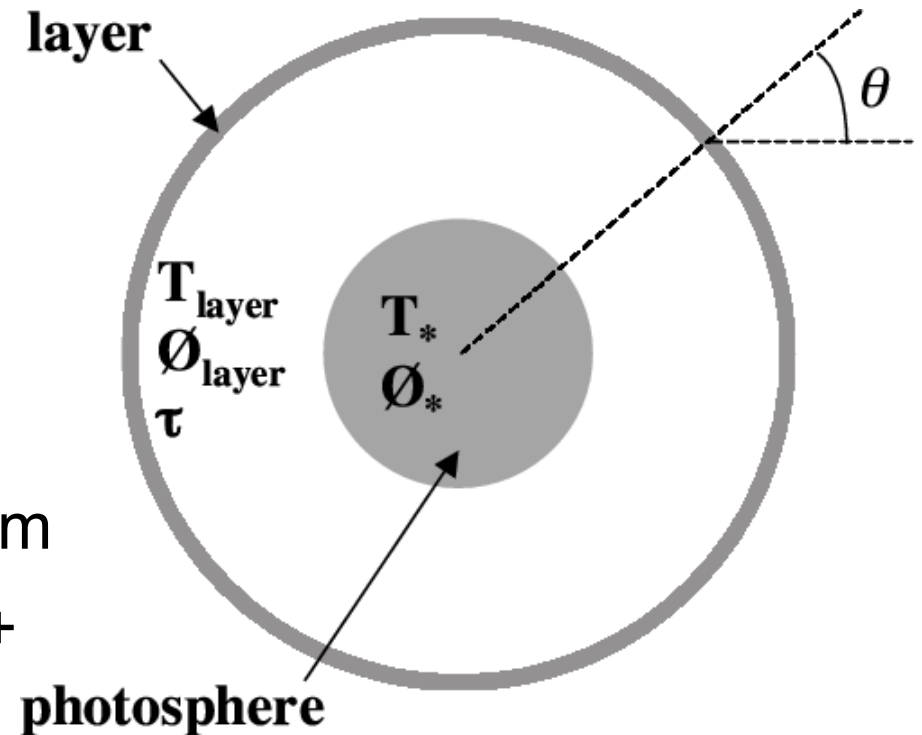
Example of the model fitting

Visibility function of period 2001-2-3

An example in practice

$\emptyset_* = 2.1+-0.6$ mas / $\emptyset_{lyr} = 4.5+-0.2$ mas / $T_* = 3990+-90$ K / $T_{lyr} = 2190+-60$ K

2.0 micron
$\tau = 0.9+-0.4$

2.2 micron
$\tau = 0.23+-0.16$

2.4 micron
$\tau = 1.00+-0.24$

Problems?
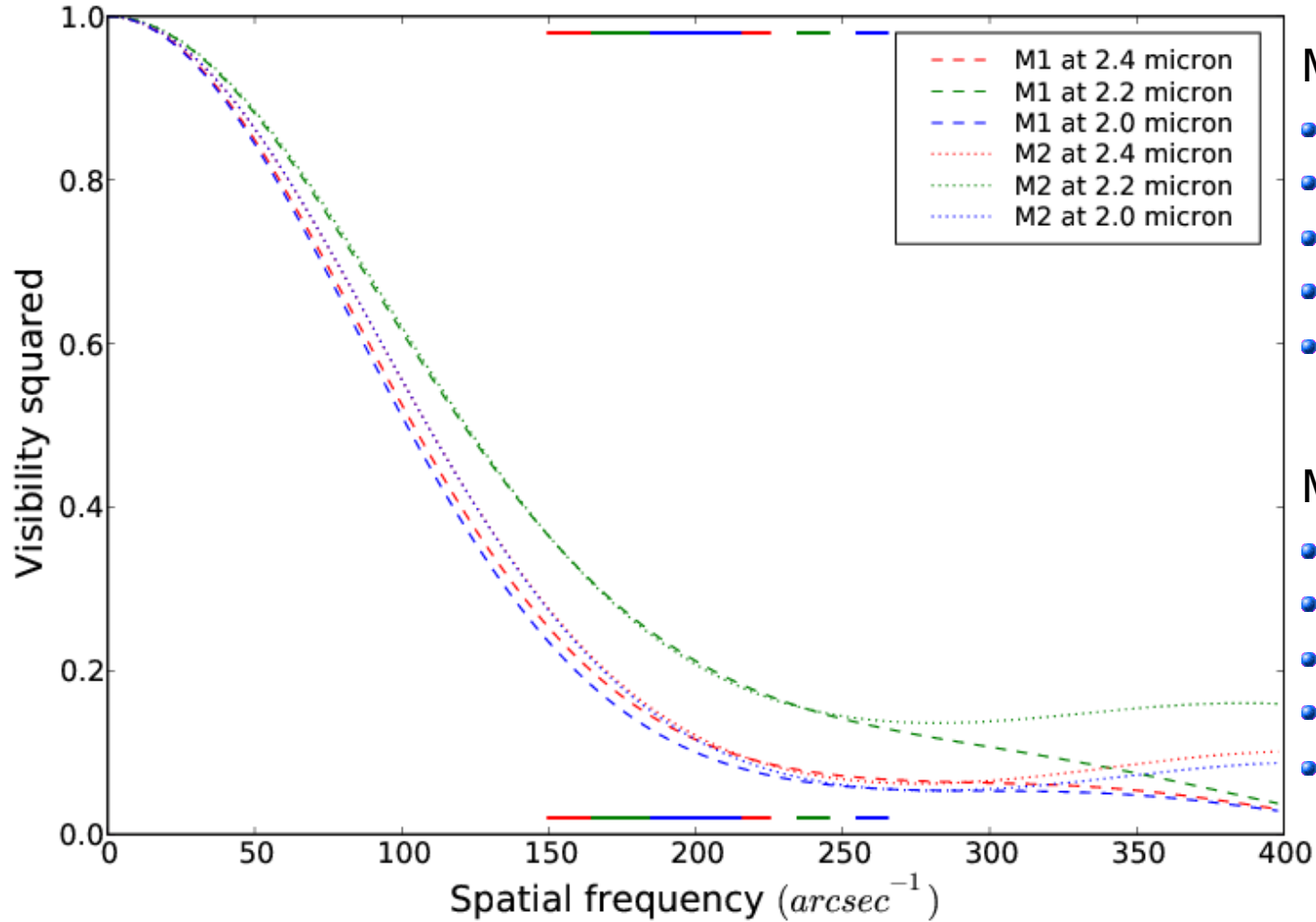
Model 1:
- Ø$_*$=2.4 mas
- Ø$_l$=6.6 mas
- T$_*$=3525 K
- T$_l$=2100 K
- τ = 0.11/0.07/0.17

Model 2:
- Ø$_*$=1.3 mas
- Ø$_l$=6.0 mas
- T$_*$=6645 K
- T$_l$=1941 K
- τ = 0.38/0.26/0.62

Legend:
- M1 at 2.4 micron
- M1 at 2.2 micron
- M1 at 2.0 micron
- M2 at 2.4 micron
- M2 at 2.2 micron
- M2 at 2.0 micron

Visibility squared vs Spatial frequency ($arcsec^{-1}$)

Preliminary conclusions and prospects

- Separating star and layer in R Boo successful, but extra constraints necessary (H,J band photometry)

- Work in progress, but very promising science output! Results to be confronted with our current understanding of pulsationally levitated atmospheres.

- Beware for degeneracies!

- The sample?

- The PTI-archive still has secrets to share!

Thank you for your attention! Questions?