Herschel results: Stellar and Circumstellar Evolution

Christoffel Waelkens
Institute for Astronomy K.U.Leuven (B)
On behalf of many colleagues

Overview

- Debris disks
  - Vega
  - Beta Pictoris
- Supernova remnants (Cas A)
- Evolved stars (AGB, post-AGB, PN)
  - Detached shells
  - Circumstellar spectroscopy

Debris Disks: Vega

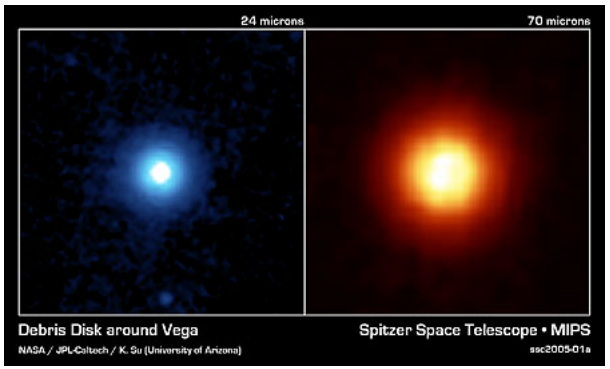
Recent massive collisions cascade versus continuous replenishment

Sibthorpe et al. (2010):

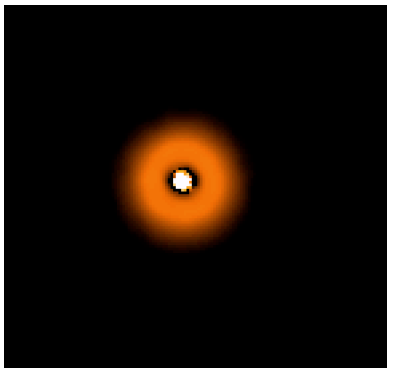
- Clearly defined ring, brightness peaks at 11”
- No evidence for clumpy substructure or spiral arm features

Observations support steady-state model

- Spitzer (24 and 70 μm)



- Herschel (70 μm)



Debris disks: Beta Pictoris

Vandenbussche et al. (2010)

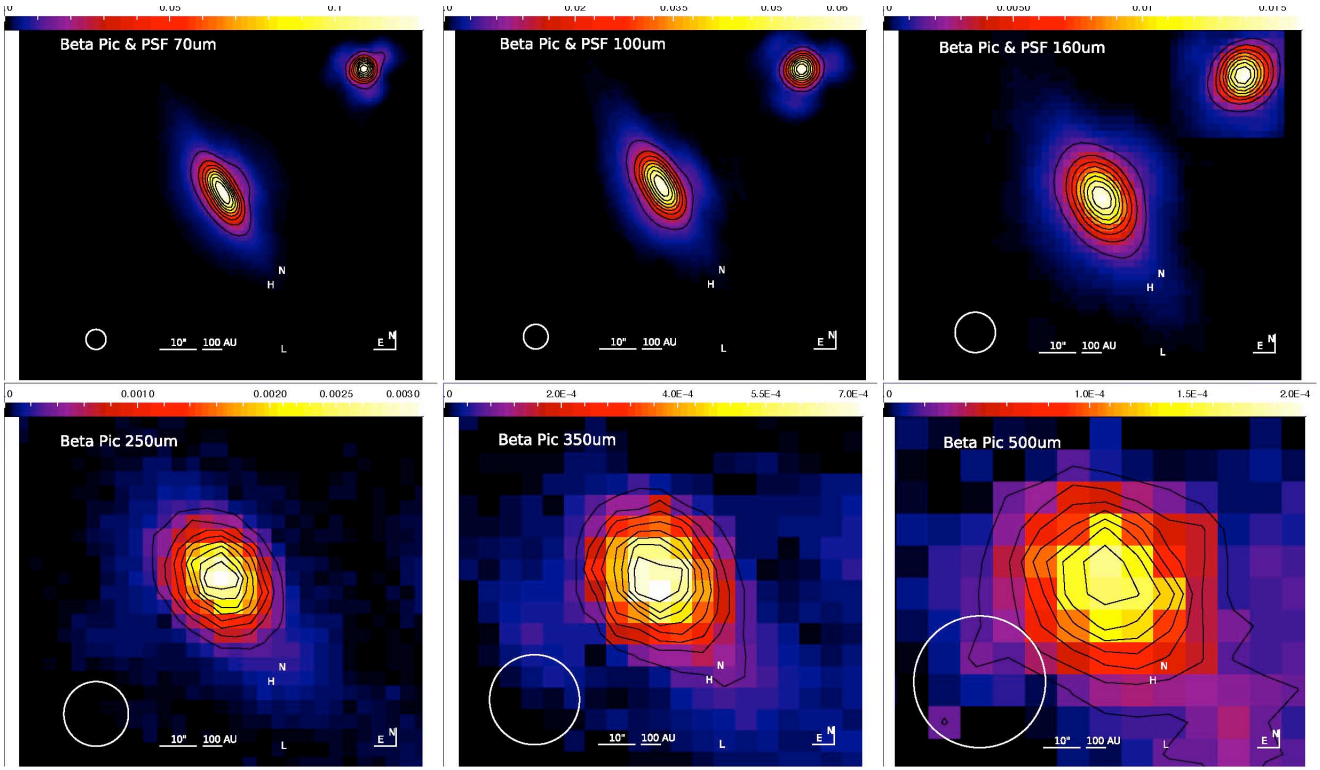
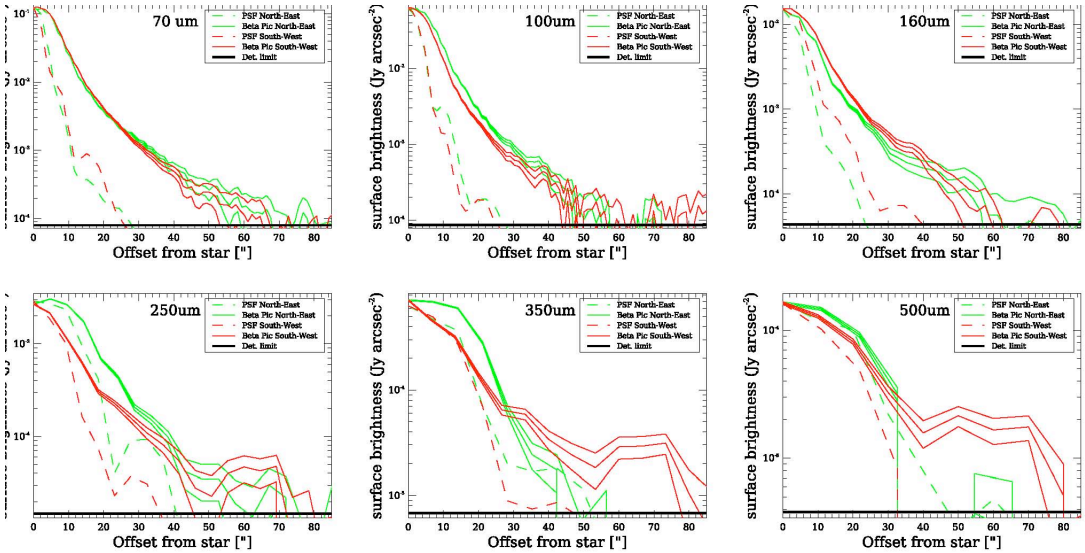


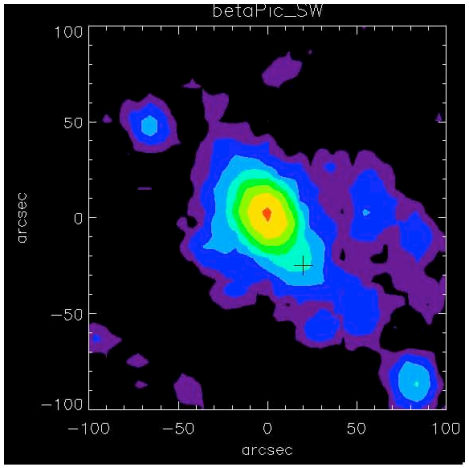
Fig. 1. Surface brightness maps of the β Pic debris disk at 70, 100, 160, 250, 350, and 500 μm. The PACS PSFs, rotated to match the position angle of the telescope at the time of the β Pic observations are depicted in the upper right corner of the images. The SPIRE PSFs are depicted in Fig. 1 (available electronically). All images are scaled linearly, contour lines are in steps of 10% of the peak flux. The surface brightness unit is Jy arcsec^{-2}. The white circle shows the beam FWHM. The position of the flux peaks observed at 850, 870, and 1200 μm by Holland et al. (1998), Nilsson et al. (2009), and Liseau et al. (2003) are indicated with H, N, and L.

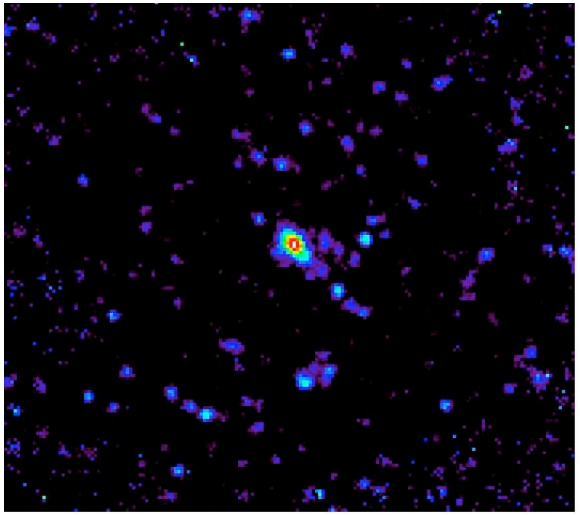
Beta Pictoris: results from mapping

Disk resolved from 70 tot 160 µm

No evident asymmetries in brightness profiles







Cold SW blob is likely to be a background source.

Beta Pictoris: far-IR SED

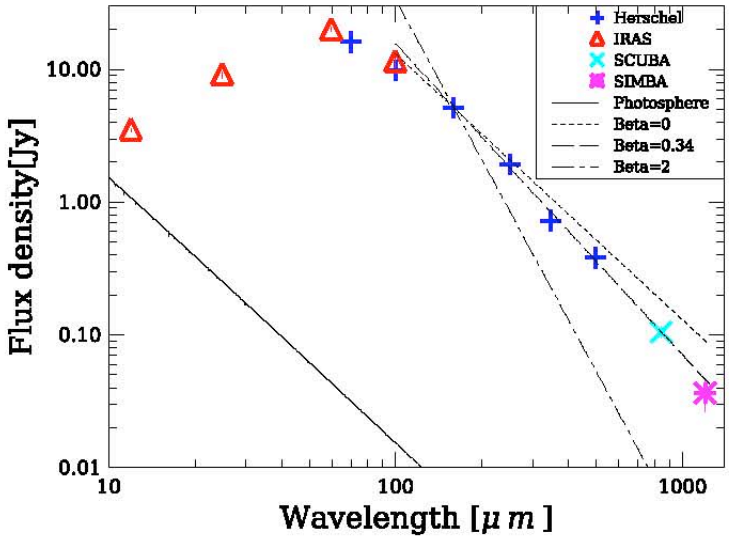
Fit with F_ν as $\nu^{(2+\beta)}$

- $\beta = 0$ for a black body
- $\beta = 1.8$ for $a^{-3.5}$ grain distribution

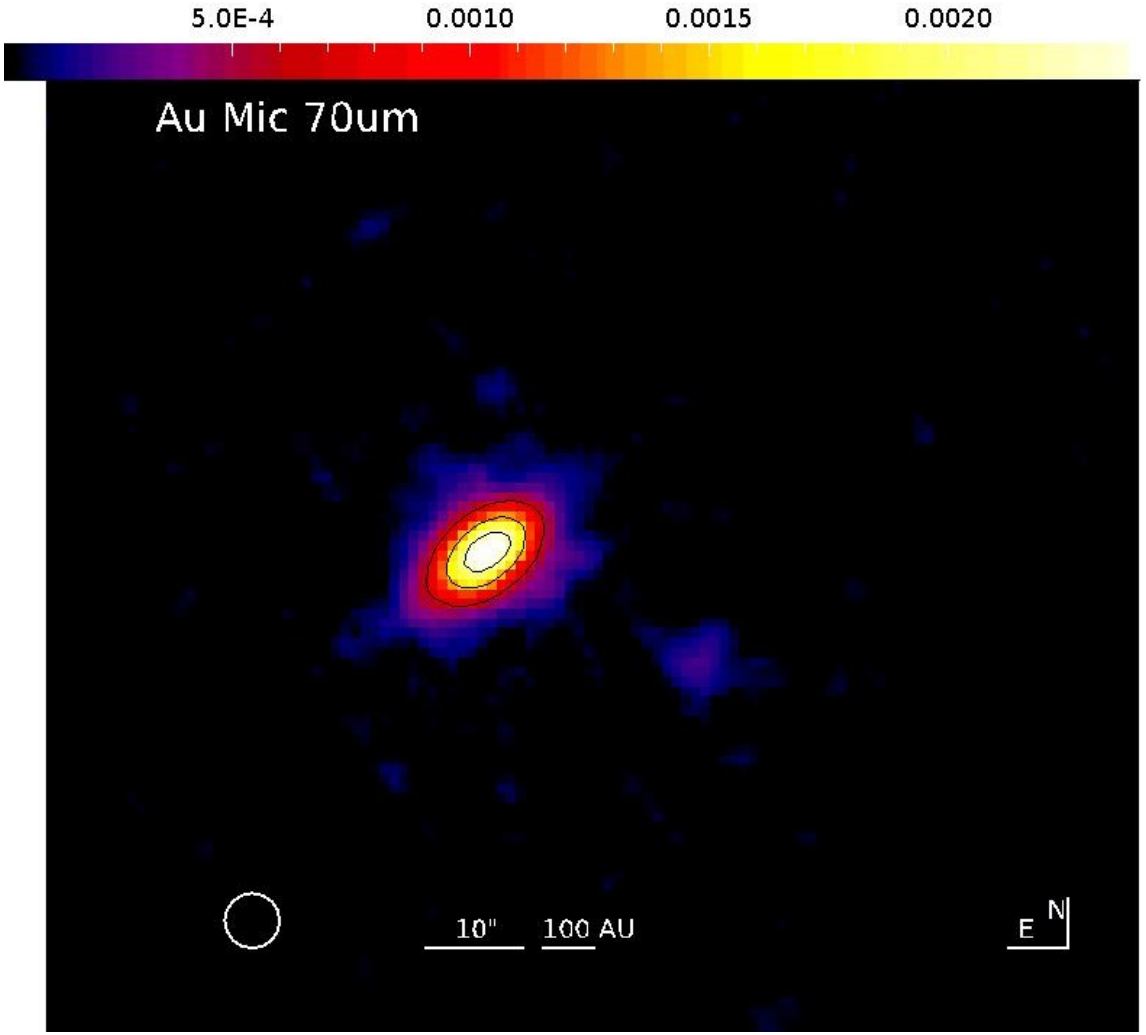
Best fit is with $\beta = 0.34$

Deficit of small grains

- Smallest grains blown away (fits with large scattering area, but does not remove fully the discrepancy)
- Other grain distribution (wavy patterns, porosity effects)

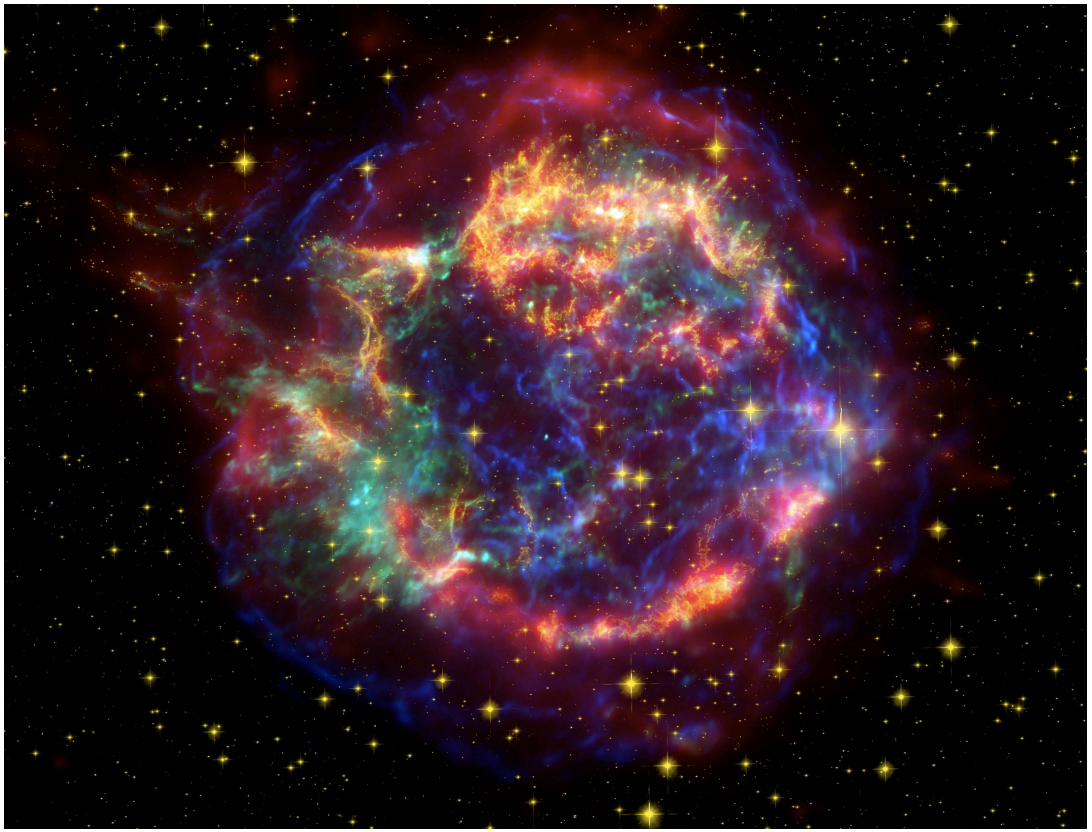


Debris disks: there is more to come



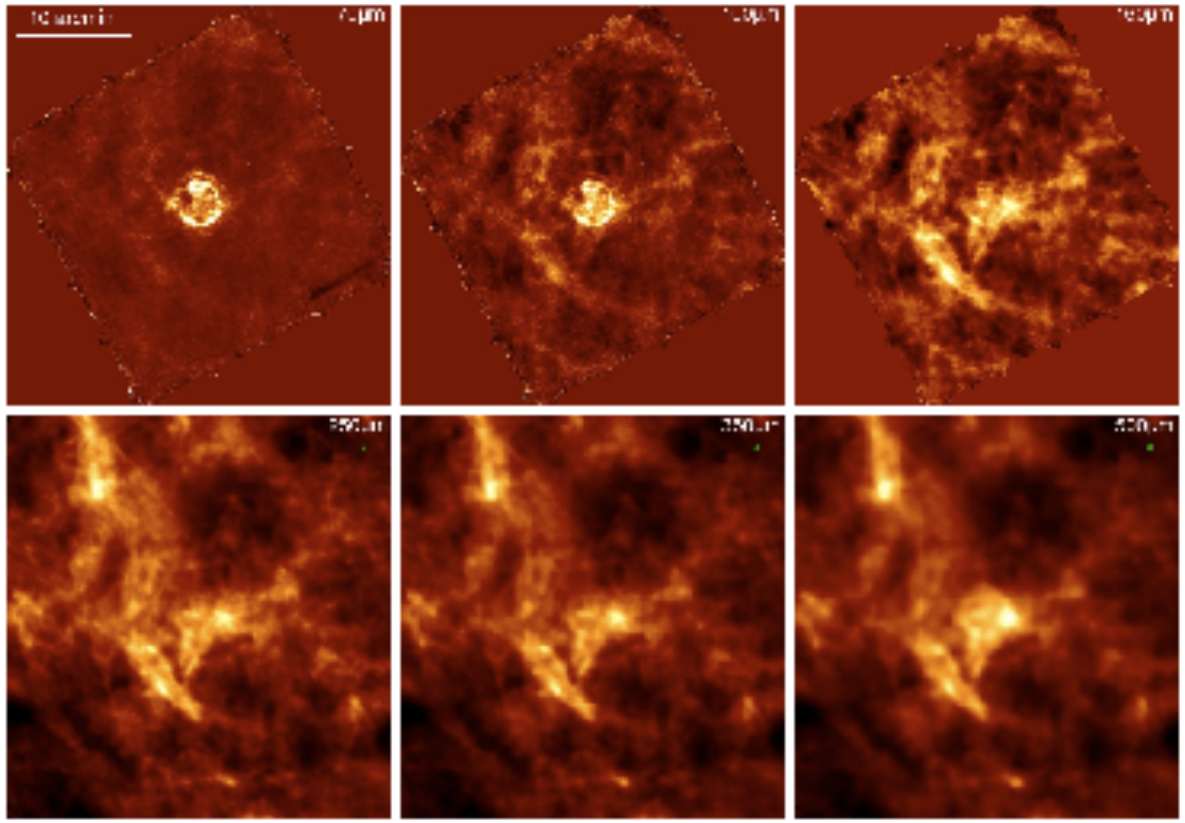
Supernova remnants: Cas A

Basic aim of the program: determine the dust mass produced by supernovae



Supernova remnants: Cas A

Barlow, Krause et al. (2010): PACS and SPIRE imaging



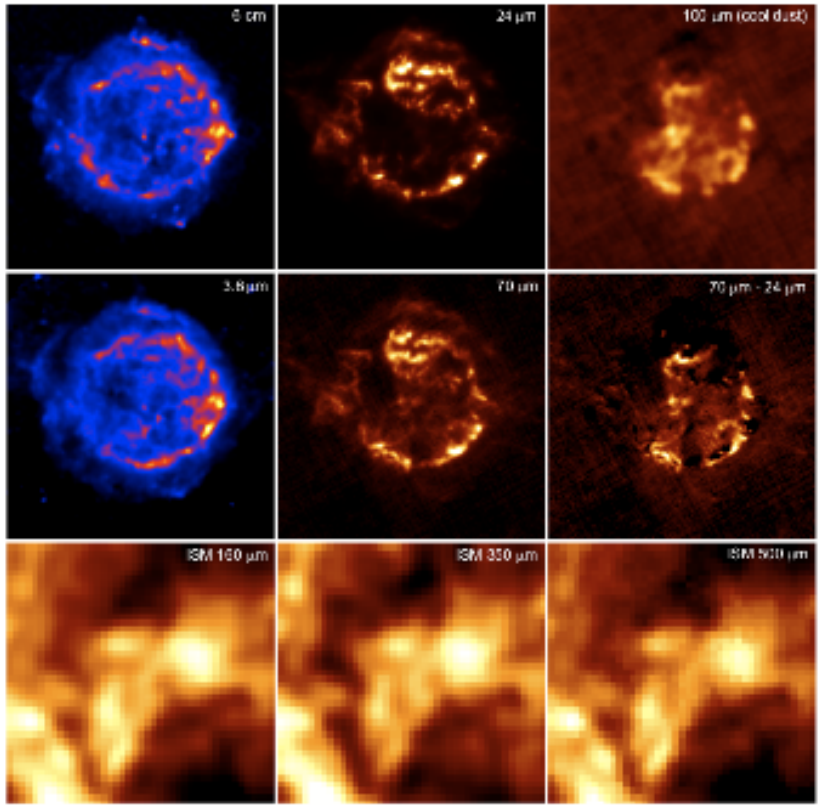
Supernova remnants: Cas A

Disentangling

- Nonthermal emission (SCUBA 850 µm and VLA 6 cm)
- Warm dust in reversed shock (MIPS 24 µm and PACS 70 µm)
- Cool SN dust (PACS 70 and 100 µm)
- Cold ISM component (PACS 160 µm, SPIRE 350 and 500 µm)

Dust inventory

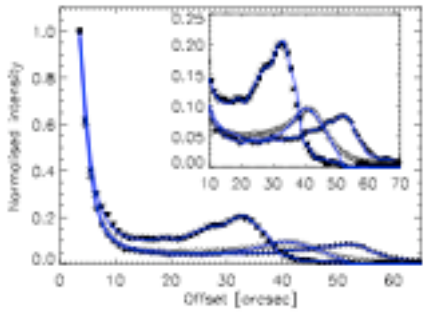
- 0.003 M_{sun} warm dust (80 K) and 0.075 M_{sun} cool dust (35 K)
- Consistent with models where 0,017 M_{sun} is produced and partly destroyed
- Not a high yield to the ISM…



Evolved stars: detached shells

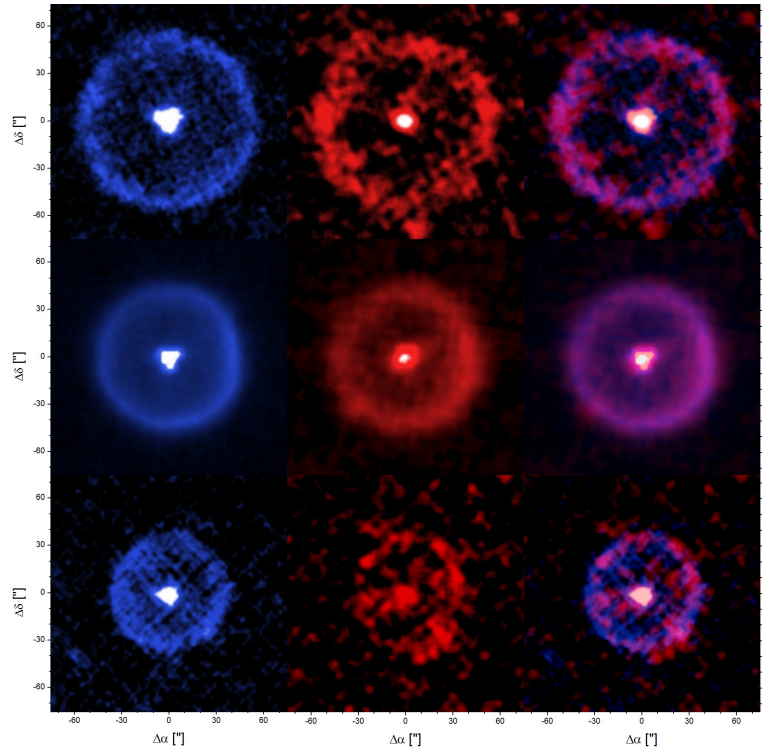
MESS program (Groenewegen et al.) to study mass-loss history

AQ And, U Ant, TT Cyg: PACS blue (70 µm), red (160 µm) and combined



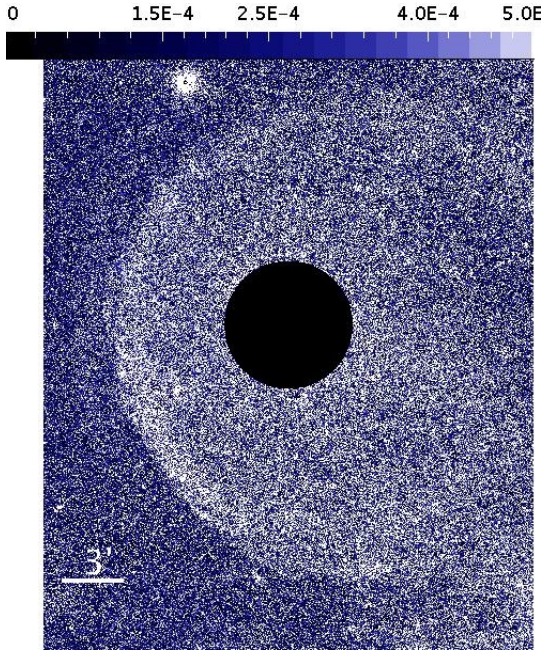
Enhanced mass (factor 10) loss episodes; relation with thermal pulses possible.

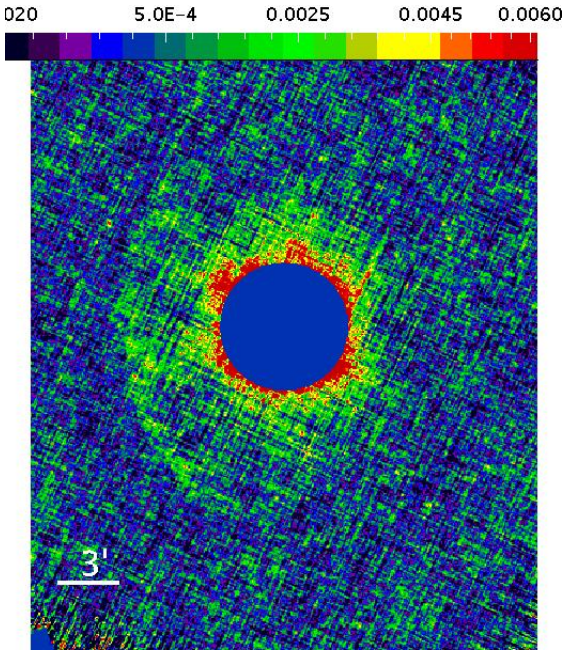
Kerschbaum et al. (2010)



Evolved stars: detached shells

CW Leonis: GALEX (Sahai and Chronopoulos 2010) versus PACS (Ladjal et al. 2010)



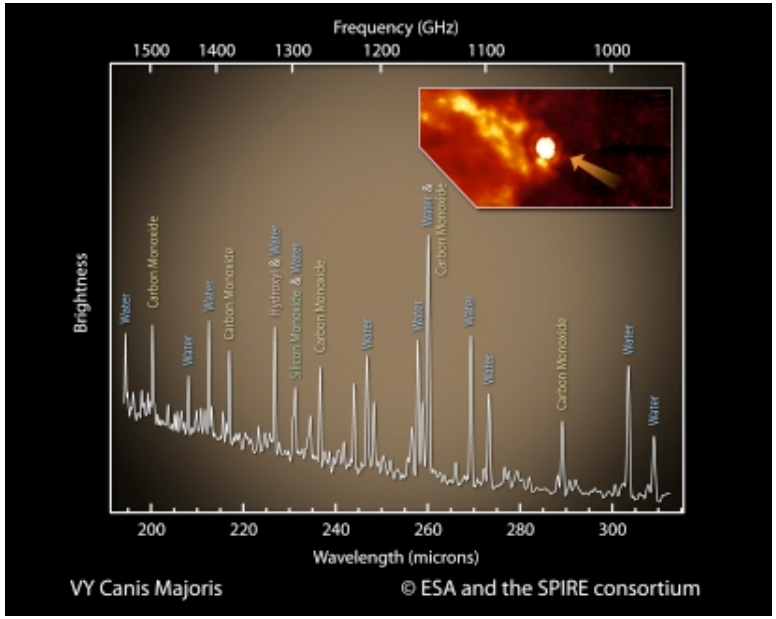


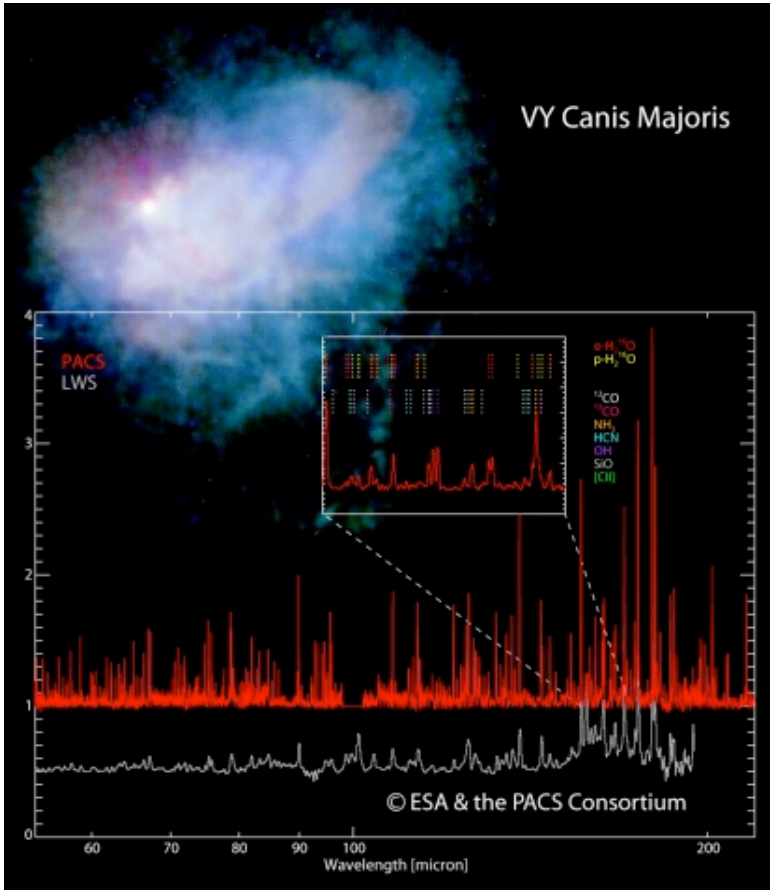
Enhanced mass loss episode + bow shock with ISM

Detailed modeling requires high ISM density or unusually large velocity.

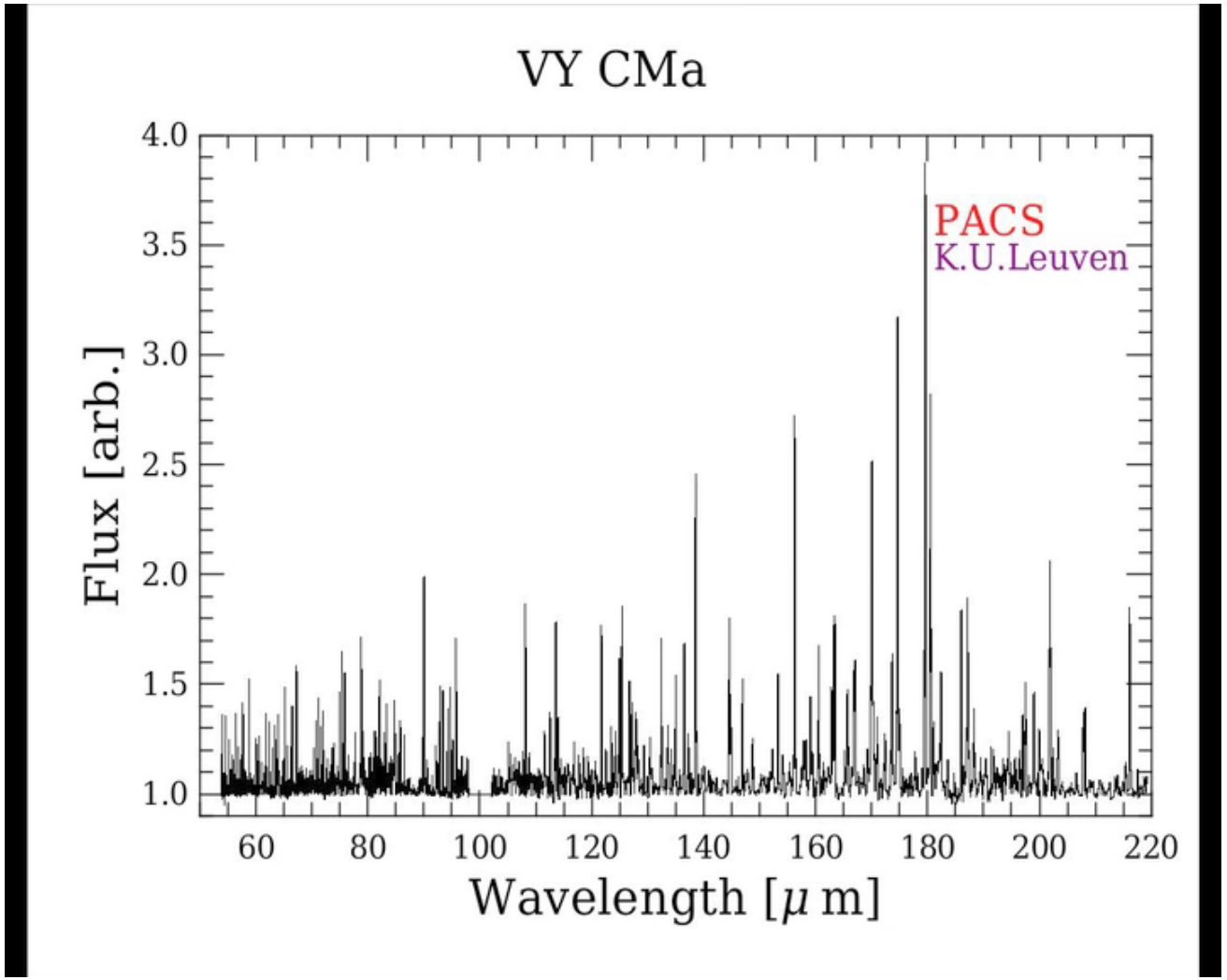
Evolved stars: molecular diagnostics

VY CMa (Royer et al. 2010)





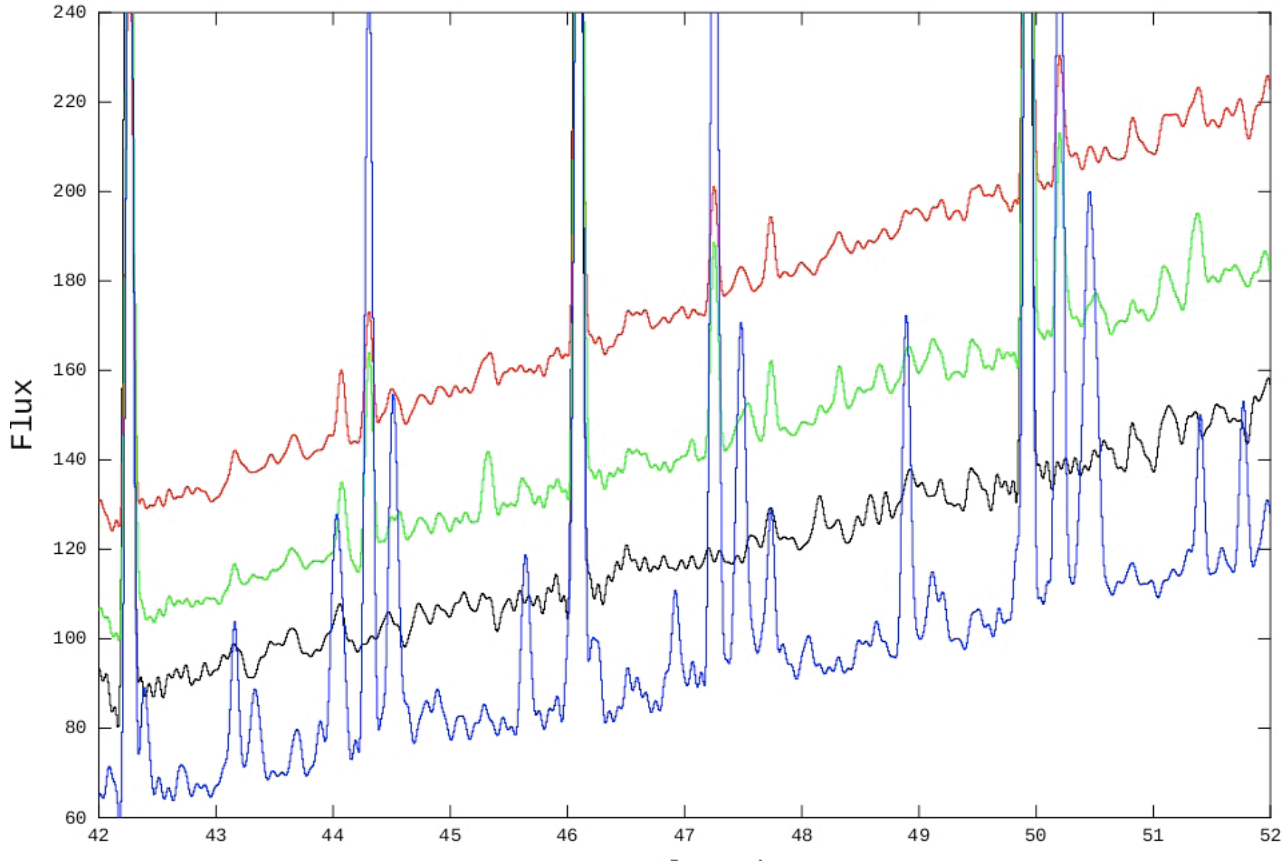
Evolved stars: molecular diagnostics



Evolved stars: molecular diagnostics

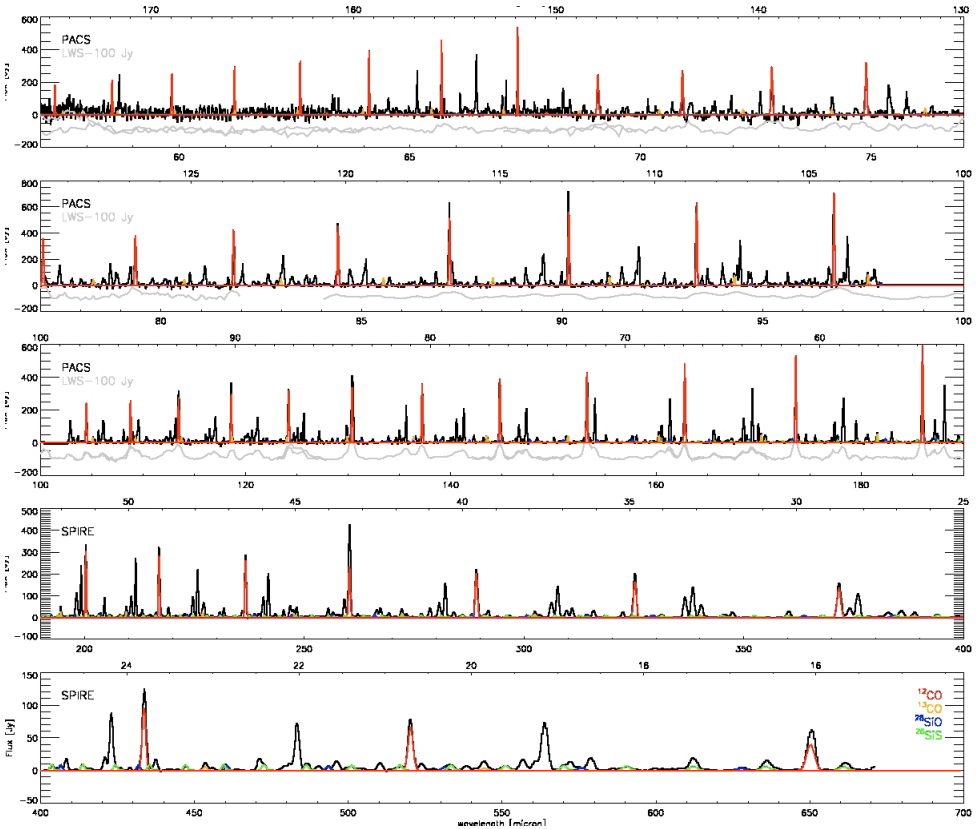
Carbon-rich sources: AFGL2688, AFGL618, NGC7027, IRC+10.216

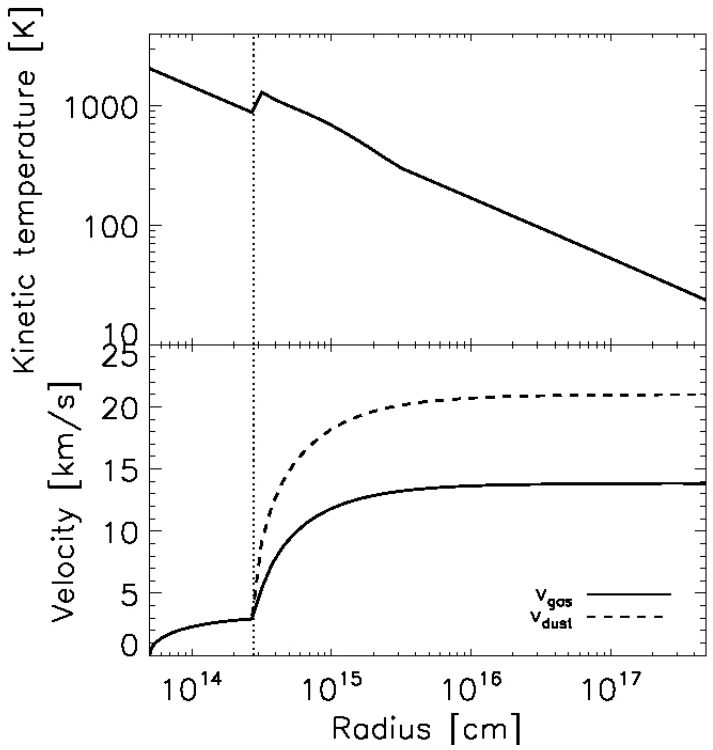
Wesson et al. (2010)



Evolved stars: molecular diagnostics

Modeling of IRC+10.216 (Decin et al. 2010): CO lines from J = 3 (31 K) to J = 47 (5853 K) determine the thermophysical structure of the envelope.





Evolved stars: molecular diagnostics

Main results on VY CMa so far:

- 400 out of 930 lines are water lines; ortho-to-para ratio is 1.3/1
- Other species detected: $^{18}H_2O$, ^{12}CO, ^{13}CO, $C^{17}O$, $C^{18}O$, NH_3, OH, SiO, HCN, CN, CS, SO, SiS, H_3O^+?
- High HCN and SiO abundances point to non-TE processes, with inner-wind pulsation-driven shocks as a possible explanation.

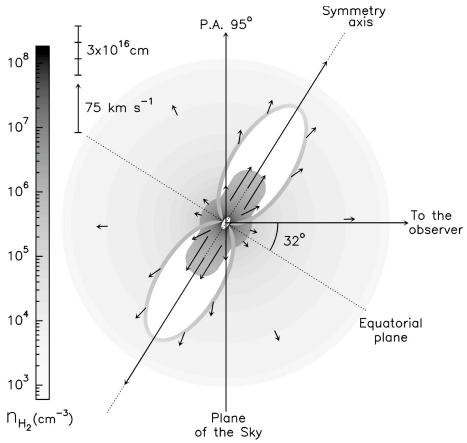
Results on CW Leo (IRC+10.216) (Decin et al. 2010, Cernicharo et al. 2010)

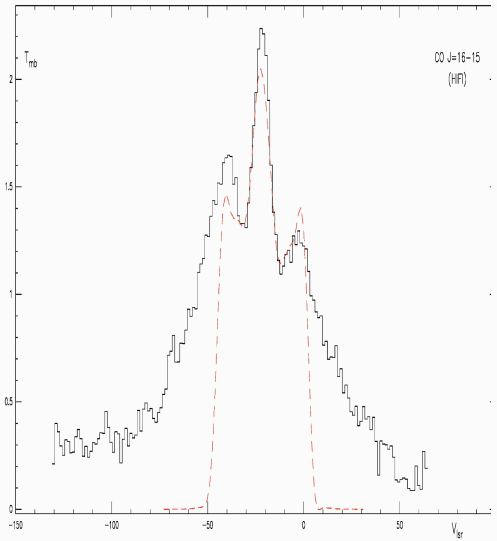
- Half of the lines are from $H^{12}CN$ and $H^{13}CN$
- Other species detected: ^{12}CO, ^{13}CO, $C^{18}O$, H_2O, NH_3, SiS, SiO, CS, C_3, C2H, HCl, CCH
- SiS and SiO as tracers of the dust-formation zone: not conclusive
- First detection of HCl in circumstellar outflow, with $HCl/H_2 = 5X10^{-8}$

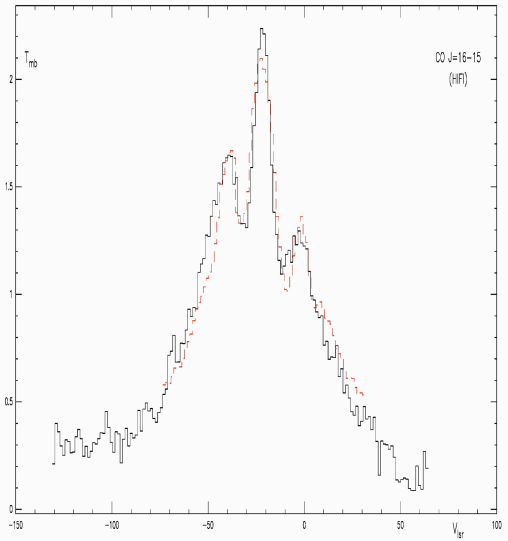
Evolved stars: molecular diagnostics

There is much more to come with HIFI.

A first flavor comes from modeling the CO lines of CRL618 (Bujarrabal et al., 2010)







- Opening a new window to the Universe
- It works according to expectation, which means that a dream becomes true.
- Don’t miss the opportunities of this cryogenic mission before the window is closed again.