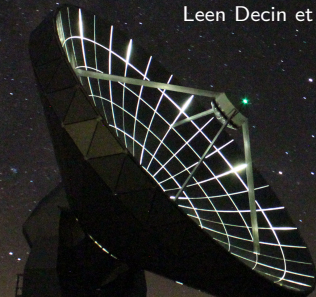


NOEMA observations of the circumstellar environment of μ Cep

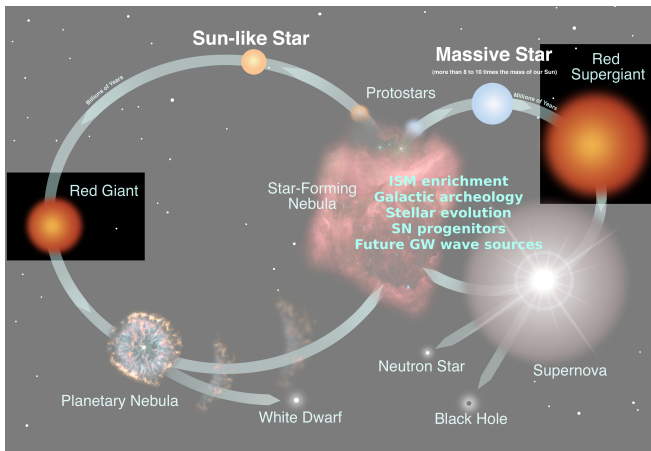
Miguel Montargès (KU Leuven, BE)
FWO [PEGASUS]² Marie Skłodowska-Curie fellow
&
Ward Höman, Denise Keller,
Nicola Clementel, Shreeya Shetye,
Leen Decin et al.



SF2A S15
Nice - 17th May 2019

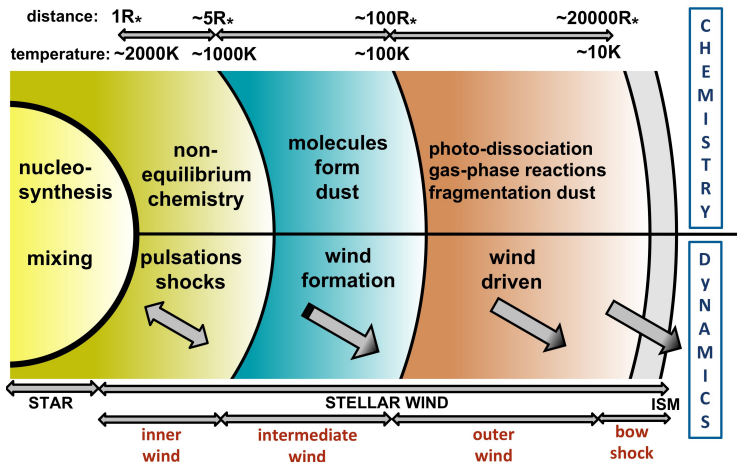
This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Grant agreement No. 665501 with the research Foundation Flanders (FWO)

The mass loss of cool evolved stars, why ?



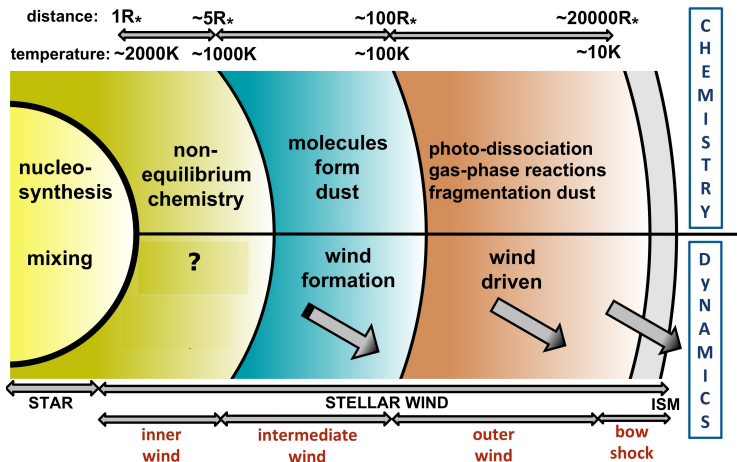
The winds of evolved stars : general picture

AGB stars

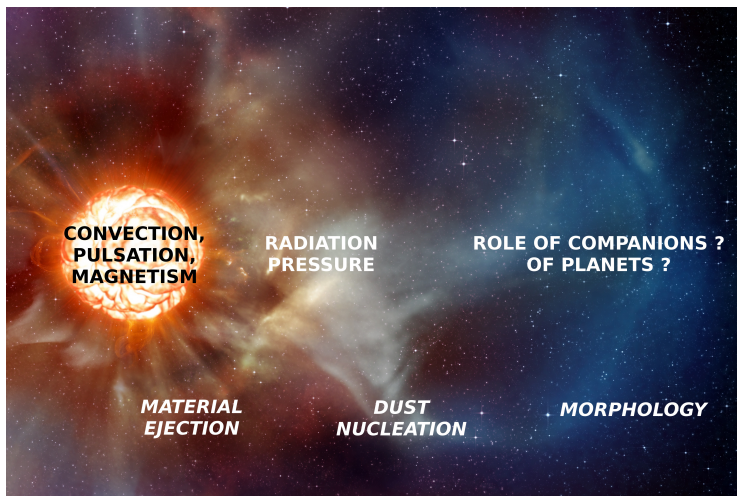


The winds of evolved stars : general picture

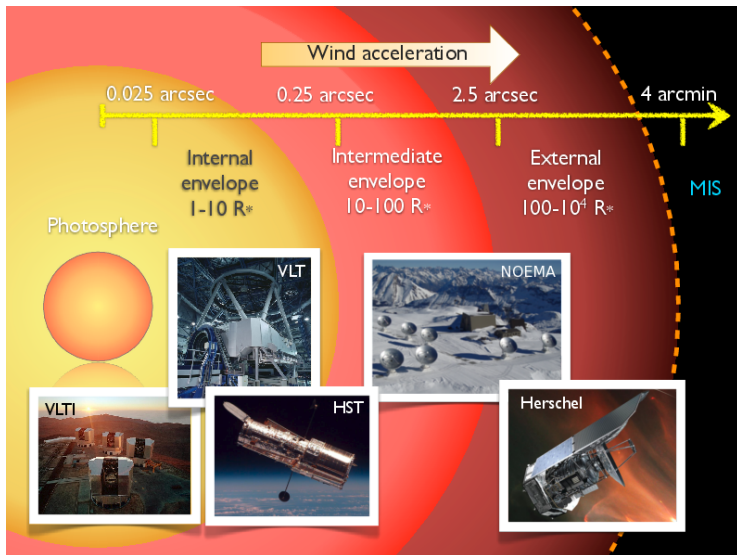
RSG stars



The winds of evolved stars : general picture



Which scales ? Which techniques ?



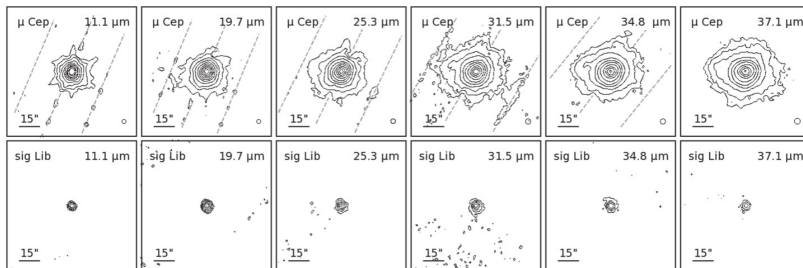
μ Cep - Herschel's Garnet Star

Parameter	Value
d (pc)	641^{+148}_{-144}
M ($M_{\odot}$)	15 – 20
R ($R_{\odot}$)	972 ± 228
T _{eff} (K)	3551 ± 136
Sp. type	M2-Ia

Montargès et al. 2019

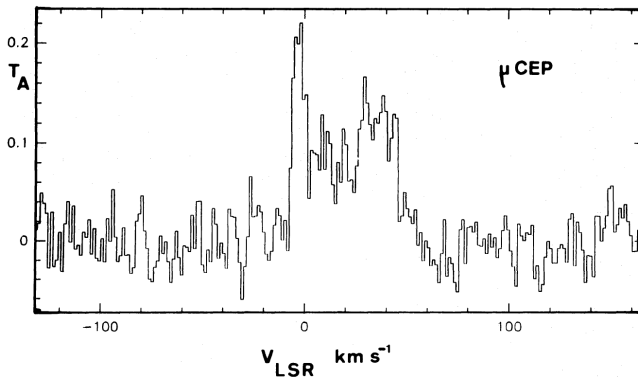


Previous observations



SOFIA/FORECAST (Shenoy et al. 2016)

Previous observations



Le Borgne & Maunon 1989

- Le Borgne & Maunon 1989 : several features ISM/circumstellar (radio)
- Maunon & Querci 1990 : asymmetries in NaI and KI lines (optical)

NOEMA

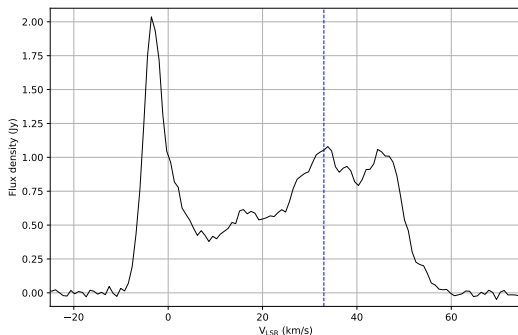


→ Characterization of the circumstellar environment

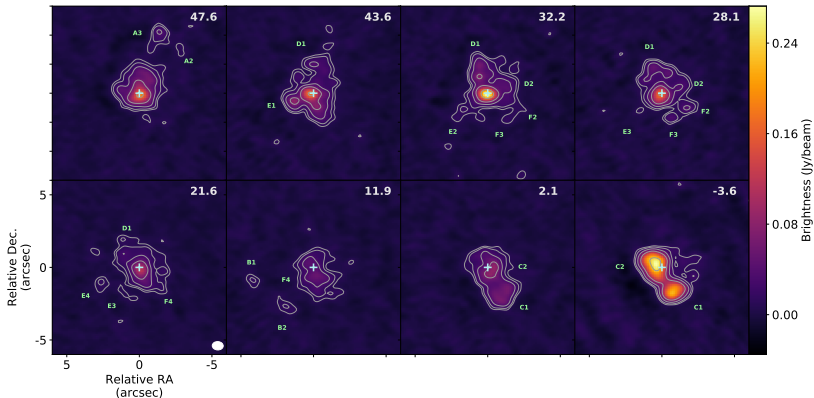
NOEMA observations

- 7B and 7C (beam = 0.93×0.70 arcsec)
- μ Cep, M2-Ia RSG, $\theta_\star \sim 0.014$ arcsec ($d = 641_{-144}^{+148}$ pc)
- CO $J = 2 - 1$ line (230.538 GHz)

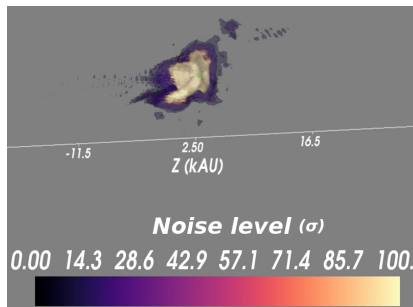
→ Montargès et al. 2019



NOEMA observations



Deprojection and mass loss rate estimate



(movie available at https://frama.link/muCep_3D)

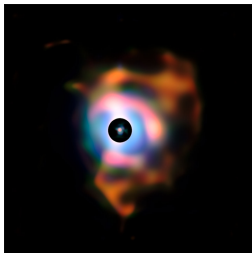
- Deprojection + radiative transfer modeling (LIME)
 - Mass loss rate : $(2.5 \pm 0.5) \times 10^{-6} \text{ M}_{\odot} \text{ yr}^{-1}$
- $\geq 25\%$ from the clumps

Conclusions

- Mass loss from μ Cep is inhomogeneous and episodic

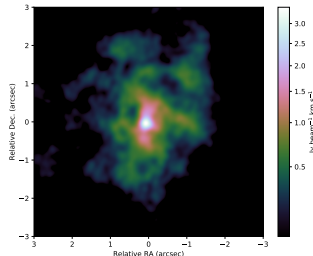
Perspectives

- 3D deprojection without hypothesis
- ATOMIUM large program on ALMA



VLT/VISIR : MIR

Dust : 2 epochs (5 yr interval)



ALMA, band 7

Gas : speed on line of sight

Kervella et al. 2011 & Montargès et al. in prep.