H I as a Tracer of Circumstellar Envelopes

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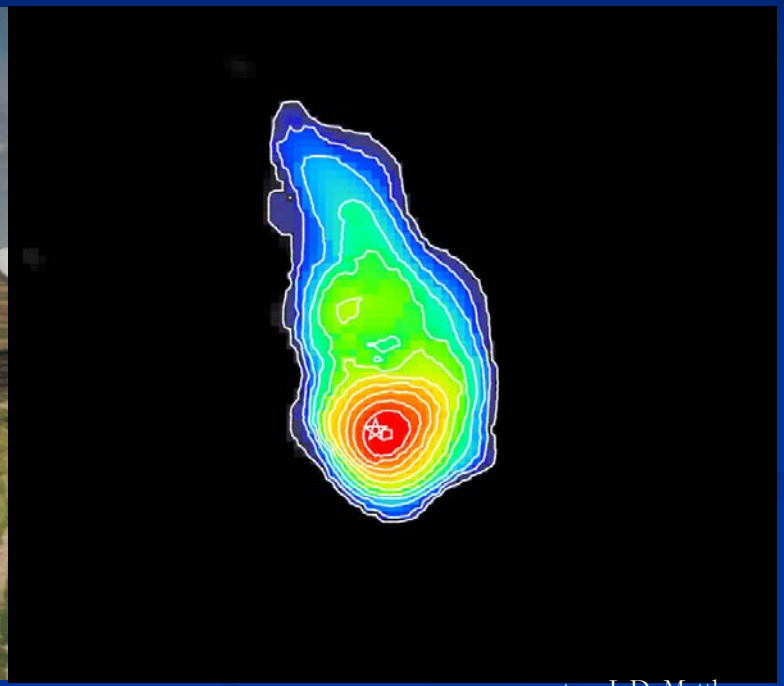

courtesy L.D. Matthews

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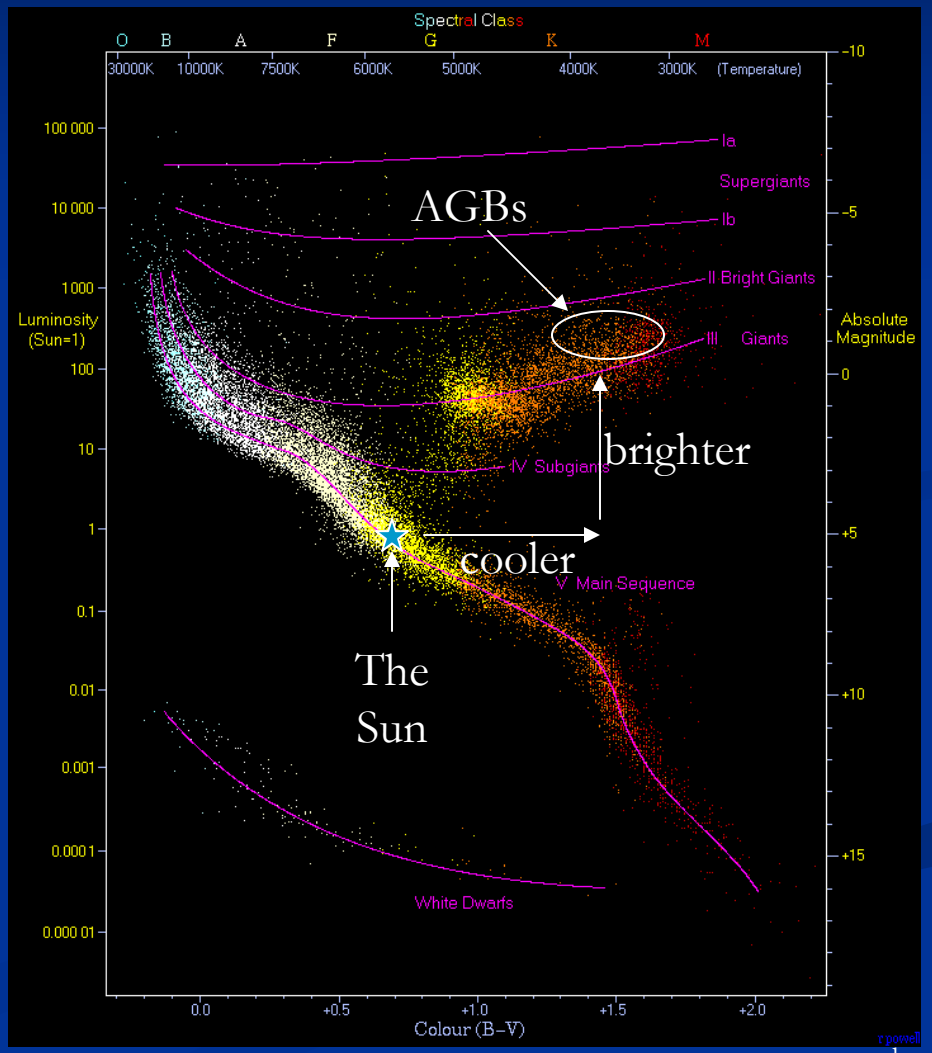
MIT Haystack Observatory REU Symposium ∞ 6 August 2009

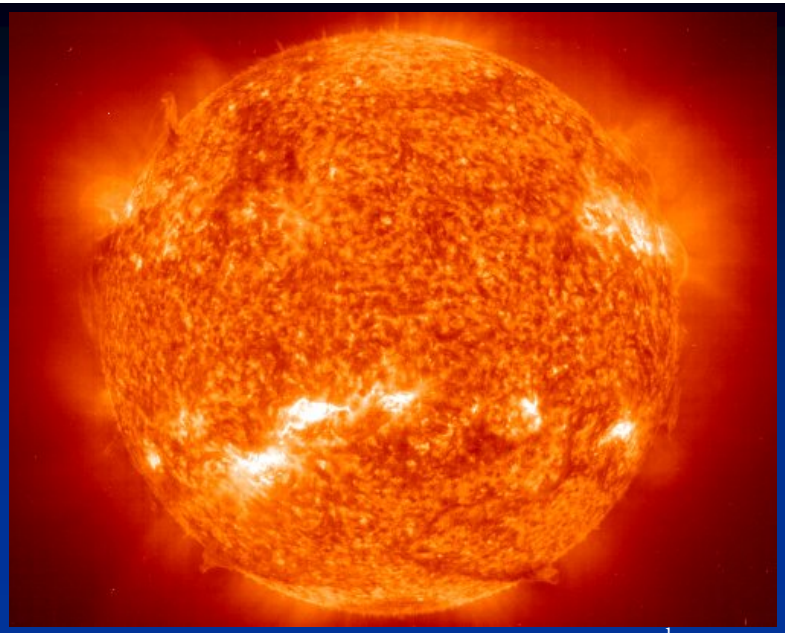
Outline

- Background: AGBs and circumstellar envelopes
- Results
  - X Herculis
  - R Pegasi
  - Y Ursae Majoris
- Conclusions and Future Work

Asymptotic Giant Branch (AGB)

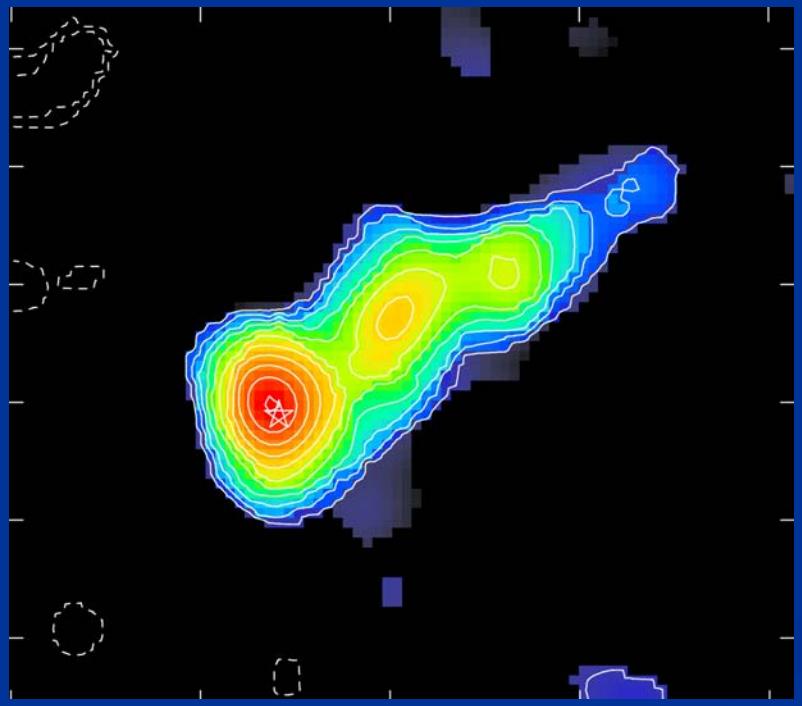
- The final stage before planetary nebula for ~solar mass stars
- Mira is the best-known example
- AGBs undergo large-scale mass loss
- This lost mass forms a circumstellar envelope





apod.nasa.gov

Circumstellar envelopes represent a precursor to planetary nebulae and seed the interstellar medium with heavy elements



courtesy L.D. Matthews

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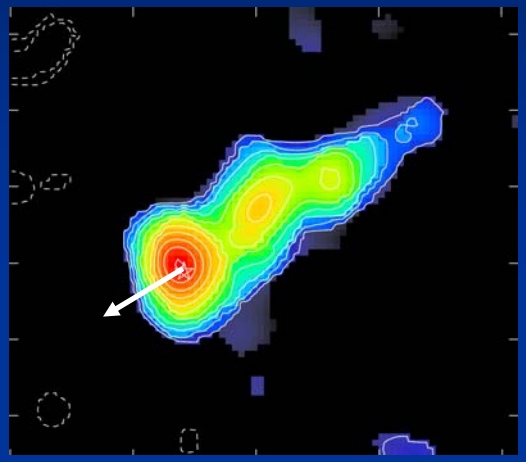
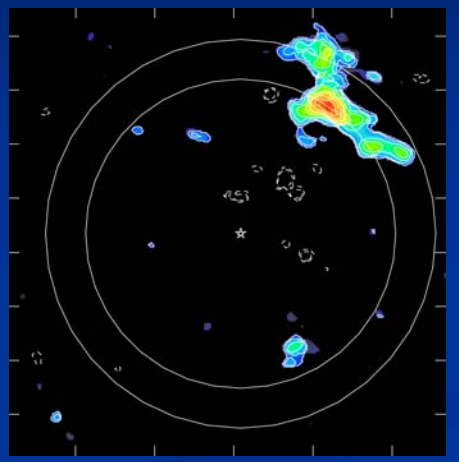
Circumstellar Envelopes

- Have previously been detected in CO, SiO, H_2O, silicate dust, and other tracers
- H I is difficult to detect—sources very faint, ~10-40 mJy—this has become possible only recently
- Previous H I (21-cm line) studies (from the Nançay Radio Telescope) were comparatively low-resolution (Gérard & Le Bertre 2006)
- 6 stars previously observed with VLA (Matthews & Reid 2007; Matthews et al. 2008)

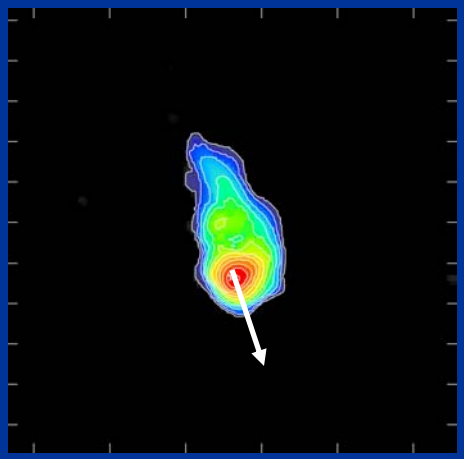
These stars exhibited either "comet"- or shell-like morphologies



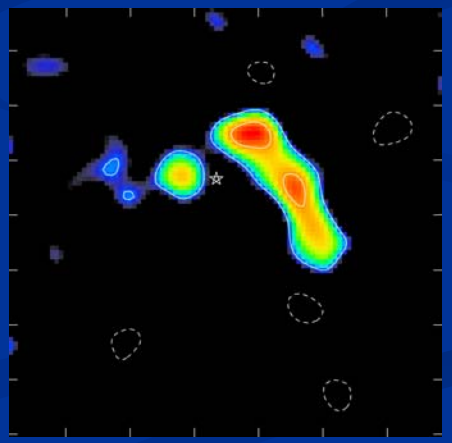
RS Cnc



IRC+10216



Mira (o Cet)



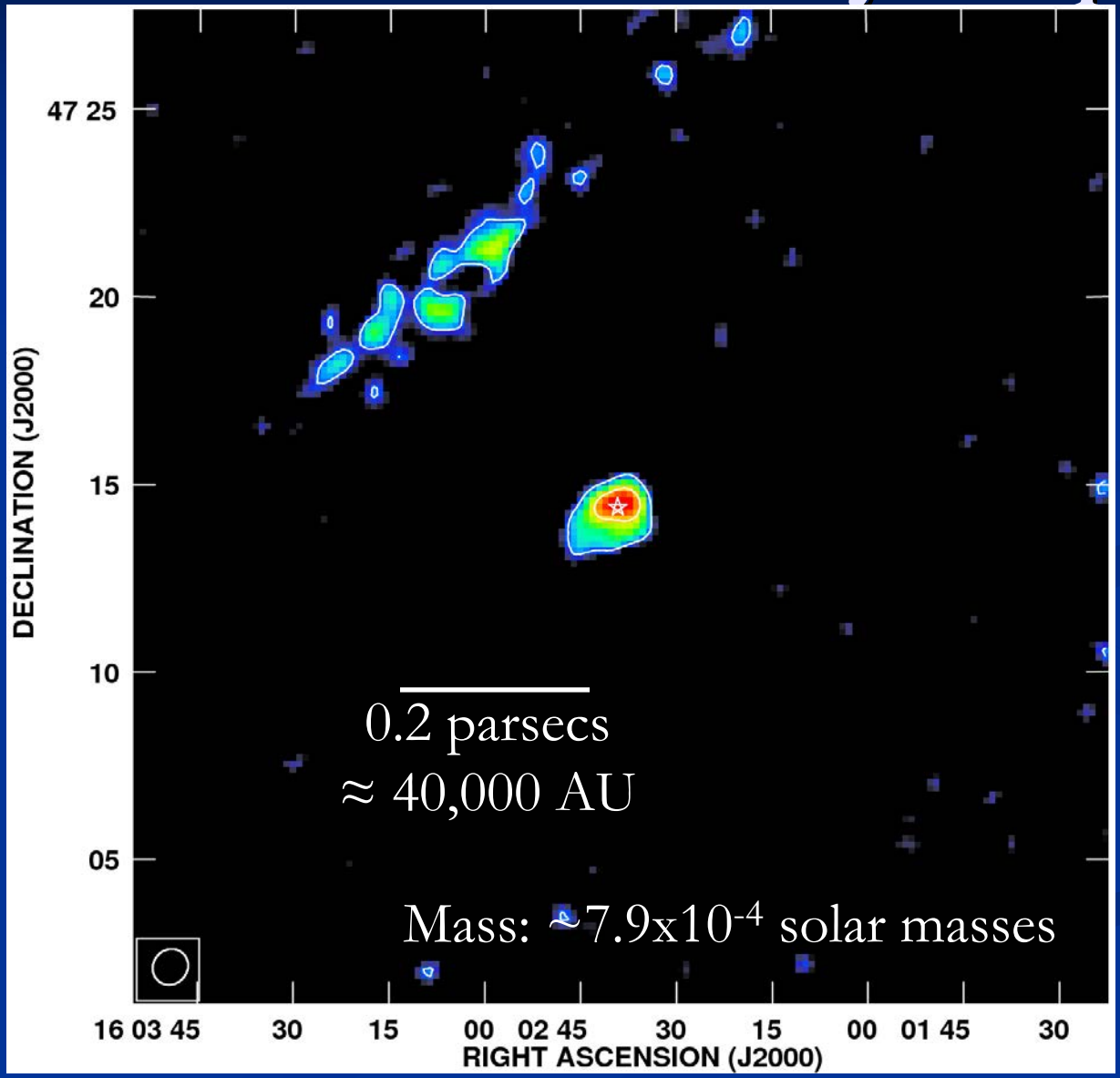
R Cas

Courtesy L.D. Matthews

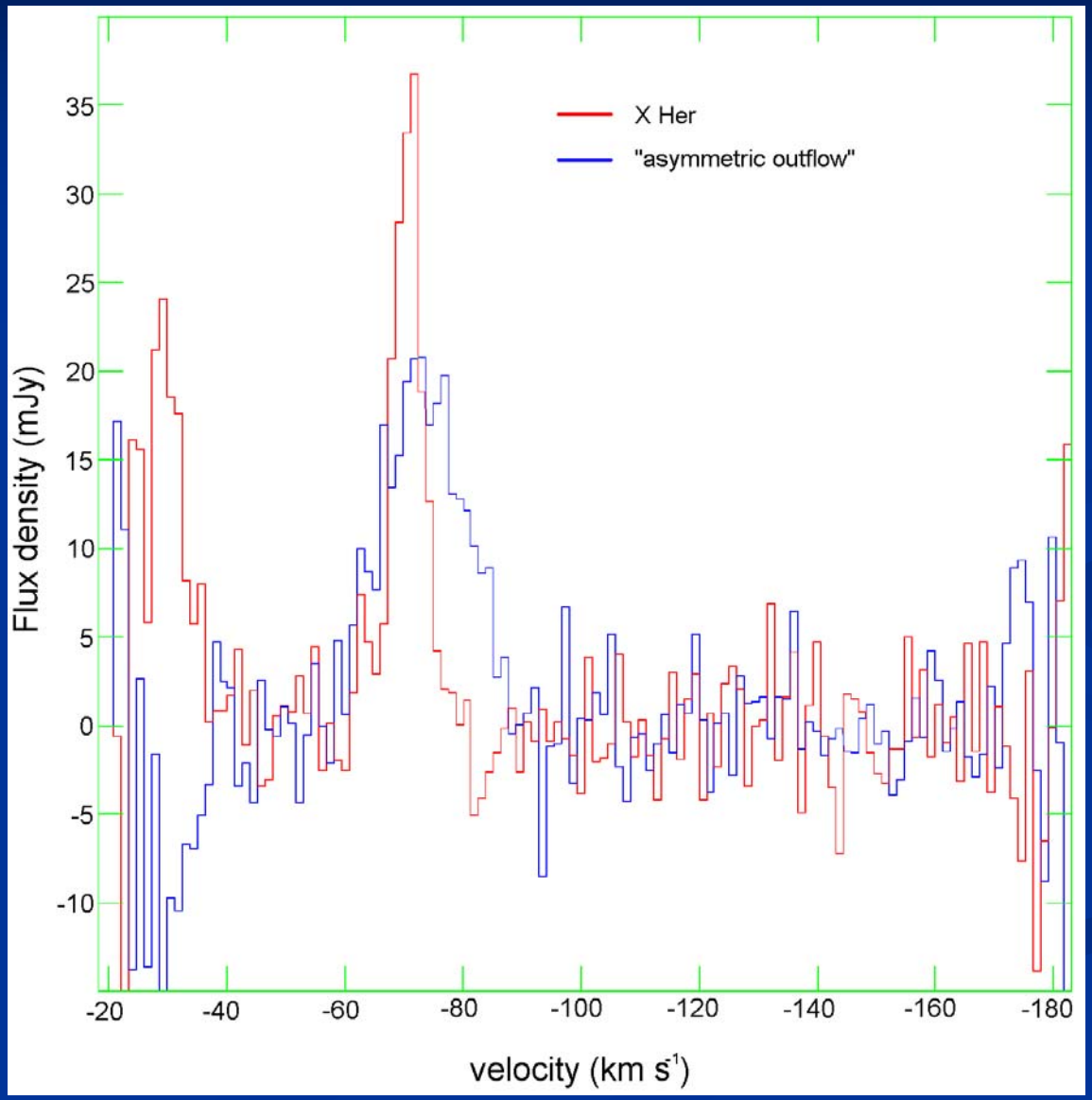
X Herculis

- Previous single-dish H I observations (Gardan et al. 2006) suggested an asymmetric outflow to the northeast

VLA Total Intensity Map

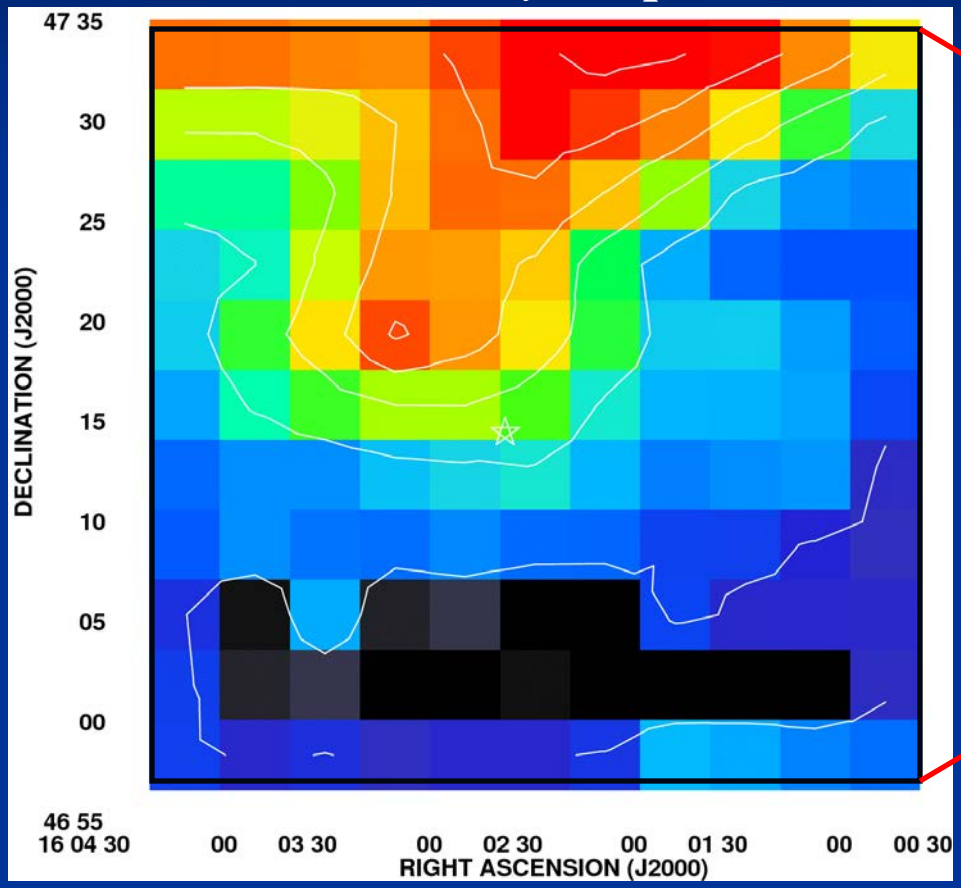


VLA Spectra


X Her
"asymmetric outflow"
Flux density (mJy)
35
30
25
20
15
10
5
0
-5
-10
-20
-40
-60
-80
-100
-120
-140
-160
-180
velocity (km s-1)

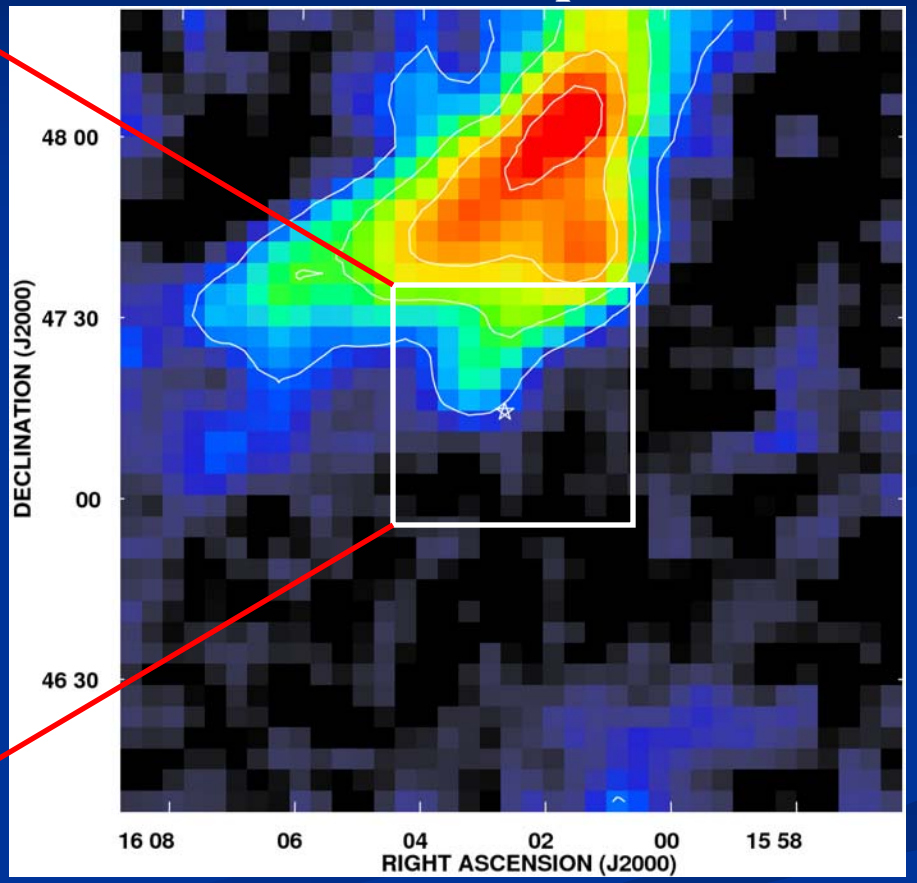
GBT Maps

On-the-Fly Map



35’ x 35’

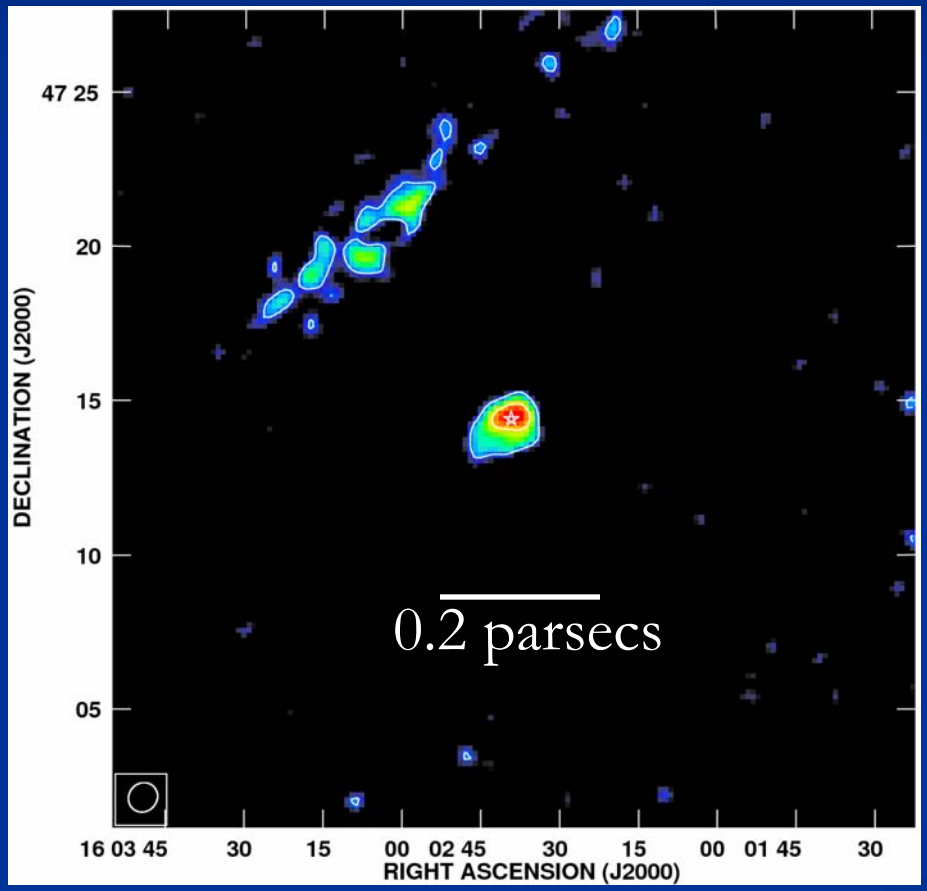
Grid Map



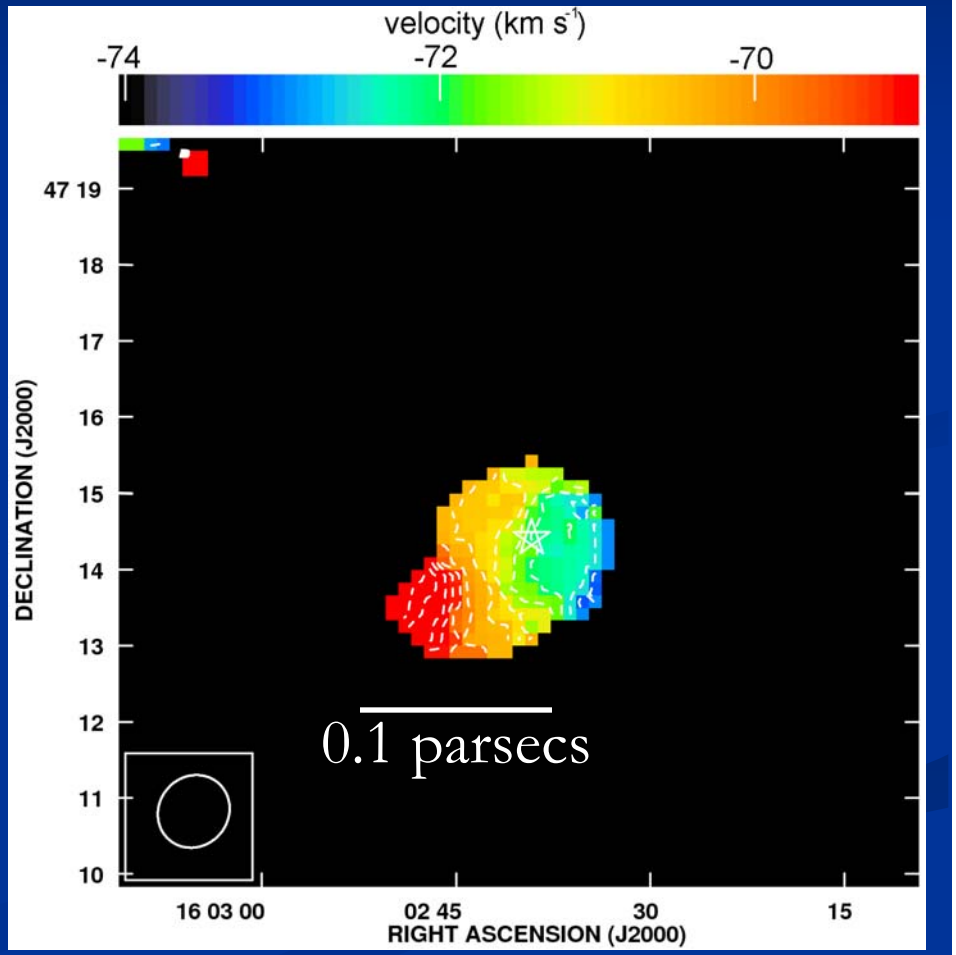
2° x 2°

Another Cometary Envelope?

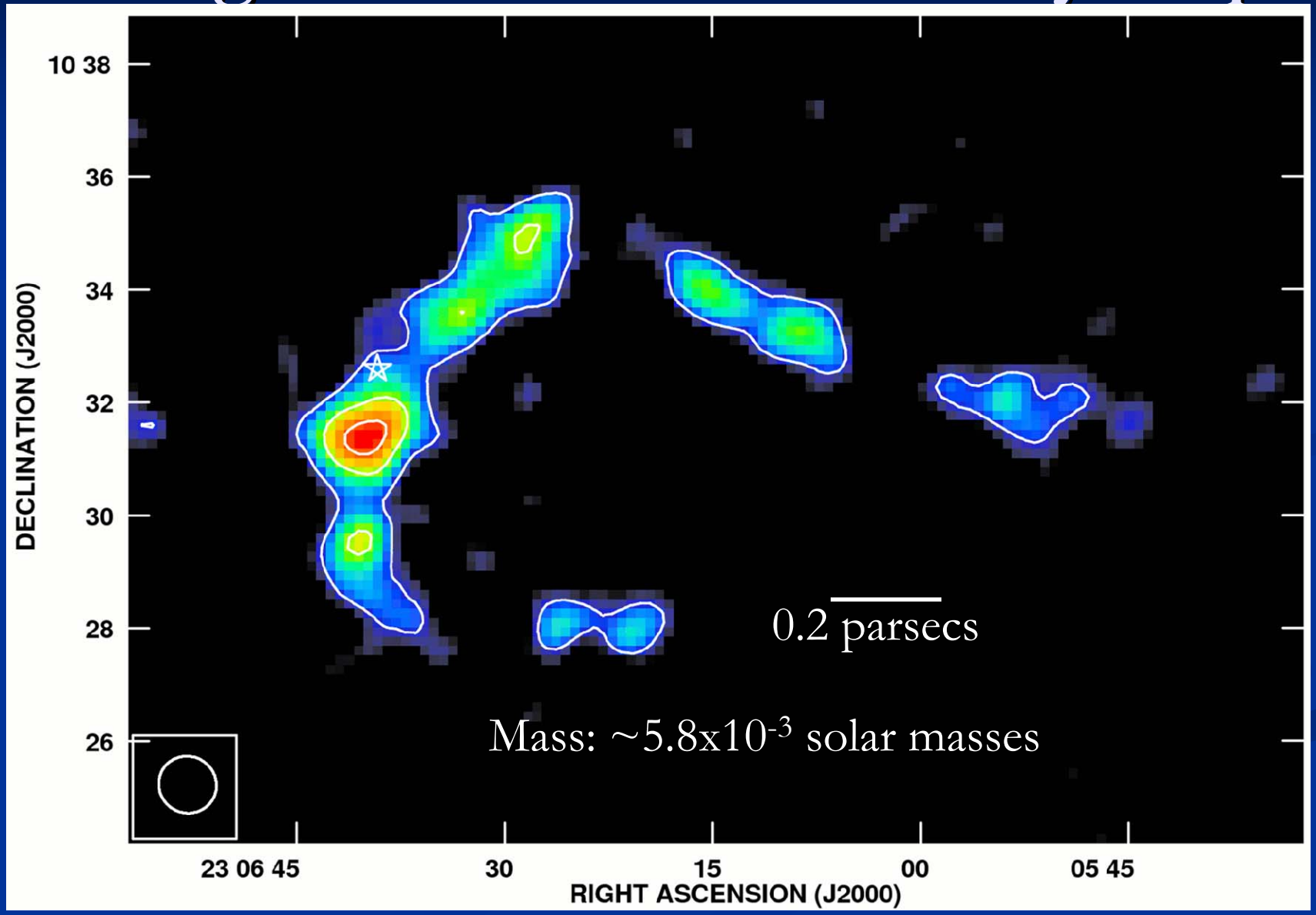
Total intensity map



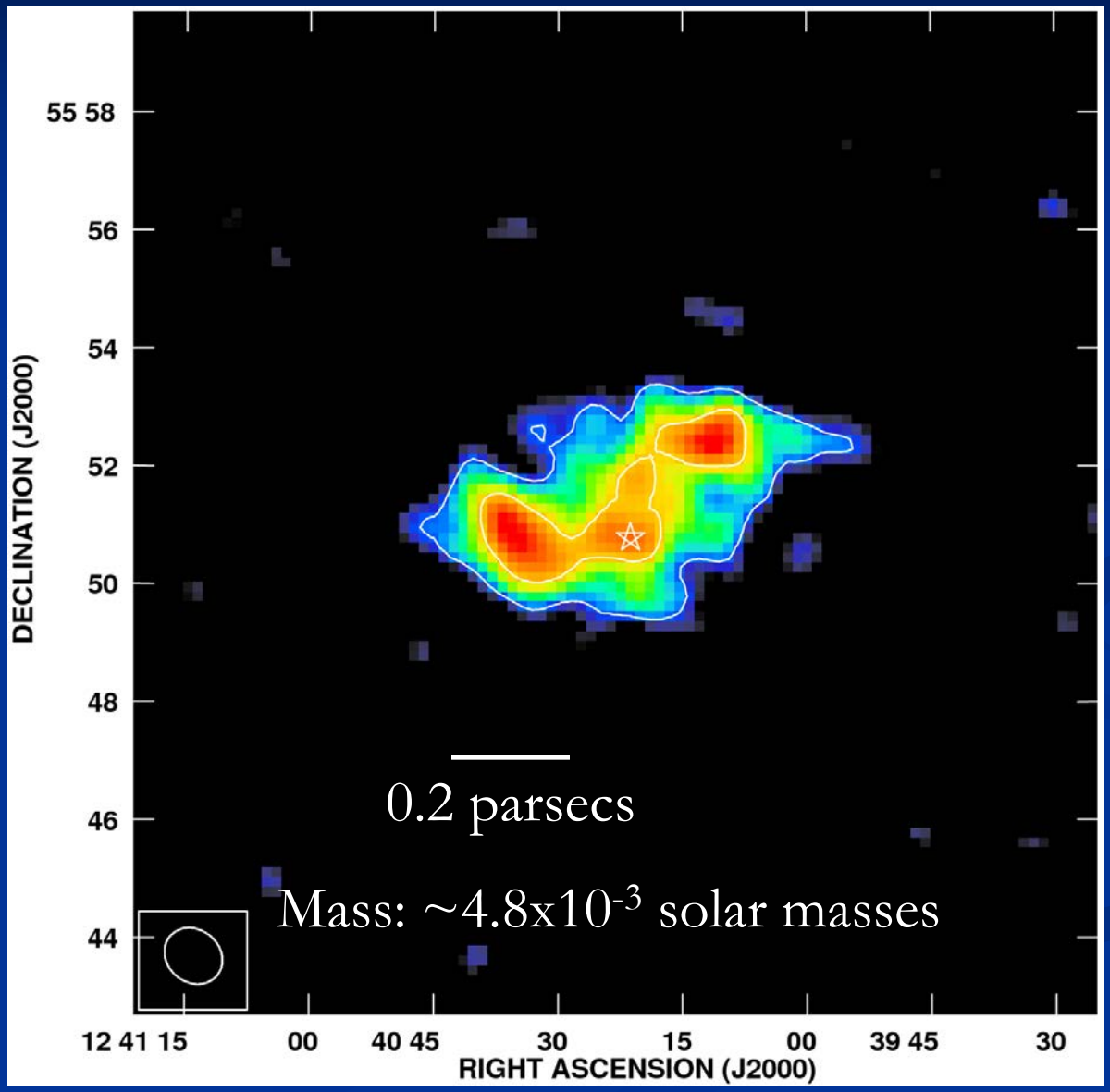
Intensity-weighted mean velocity



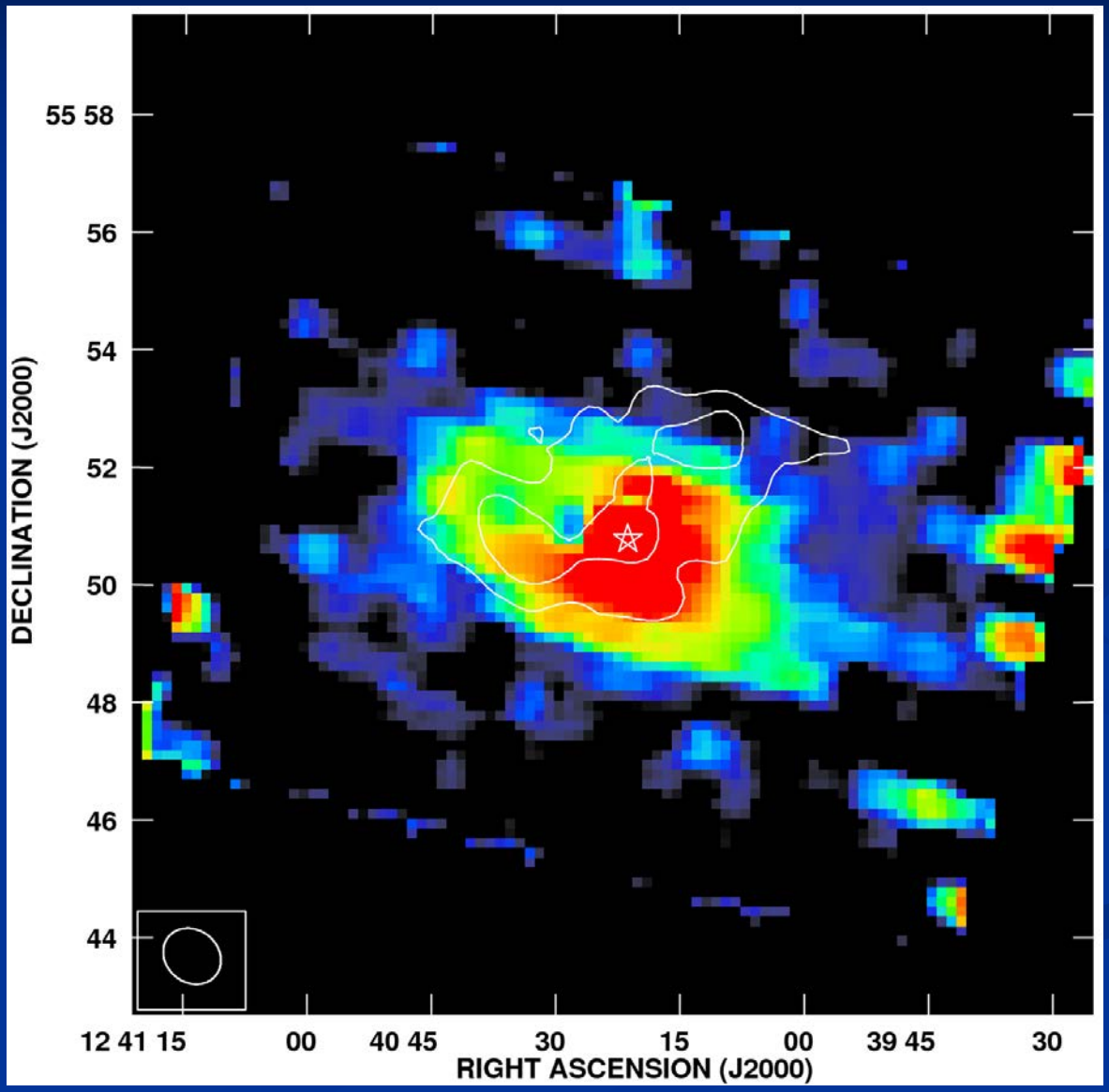
R Pegasi: VLA Total Intensity Map



Y Ursae Majoris: VLA Total Intensity Map

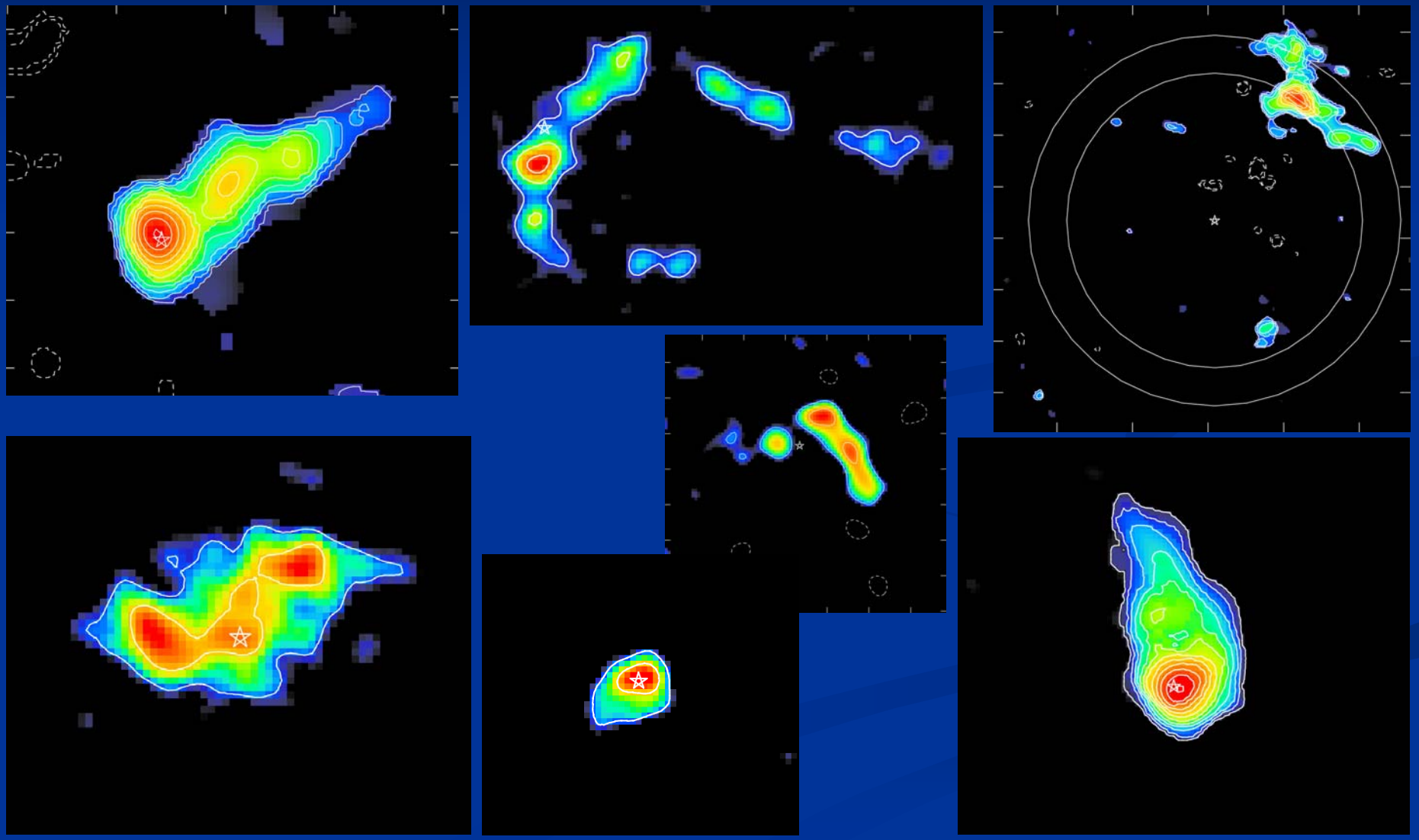


Infrared Space Observatory 60 μm Data



Archival ISO data:
Kessler et al. 1996

Envelope morphologies are more complex and varied than previously expected!



Conclusions and Future Work

- The complex morphologies seen in planetary nebulae seem to arise during the AGB stage
- This work seems to raise more questions than it answers (that's science!)
- Observations of more circumstellar envelopes are needed to gain more insight into physical mechanisms
- Clearly H I observations are a powerful tool for probing circumstellar envelopes and their interactions with their environments

Acknowledgments

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