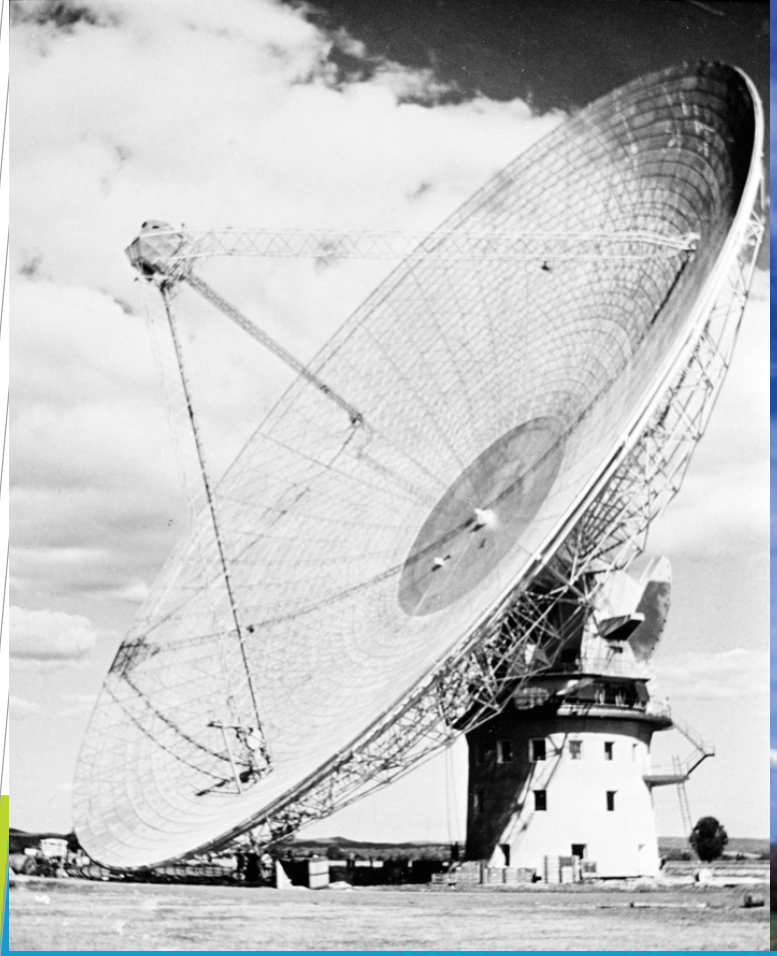

Maser Observations of Evolved stars

Jessica Chapman
CASS Observatory Operations
Research Program Leader
1 November 2011

www.csiro.au

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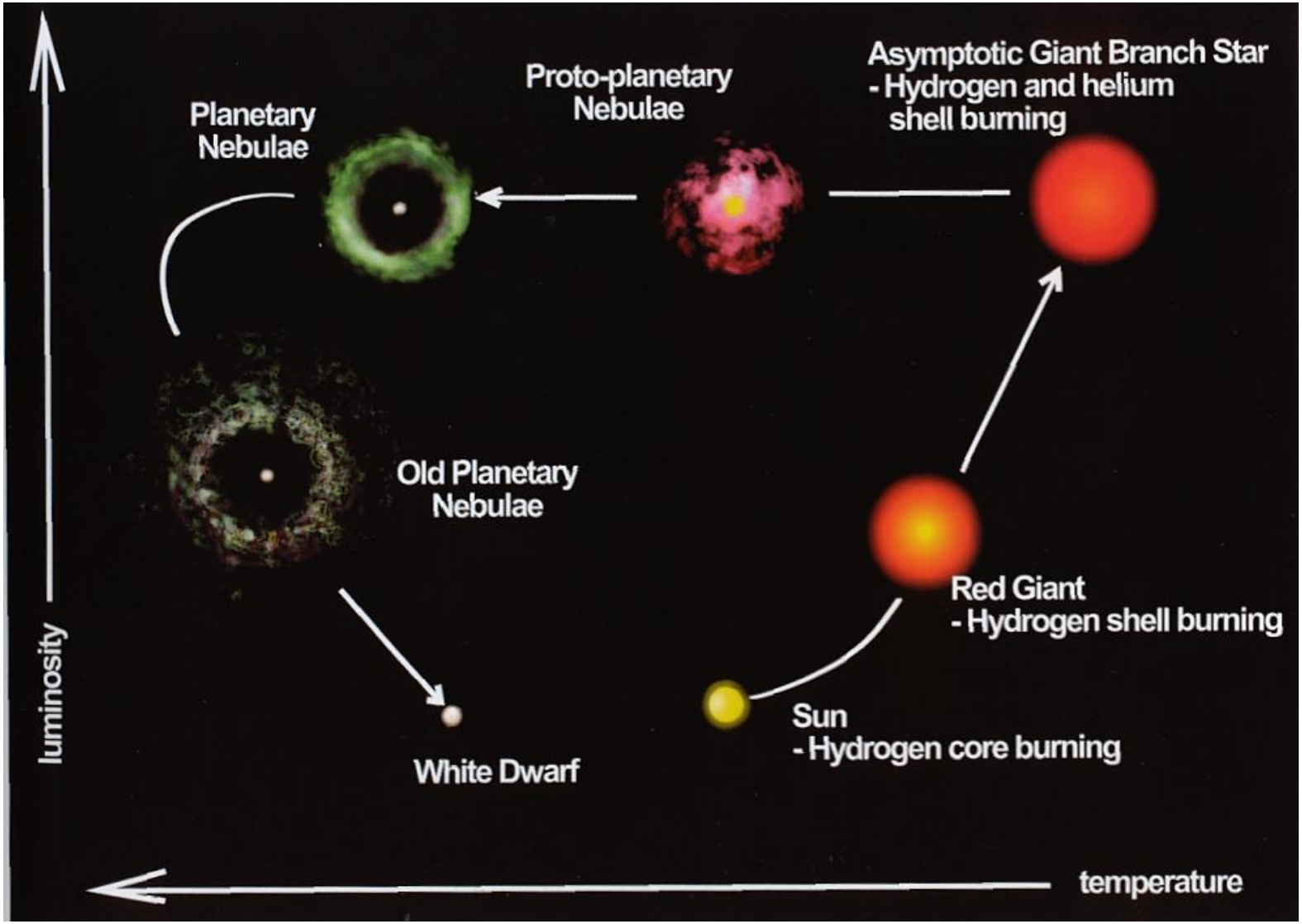
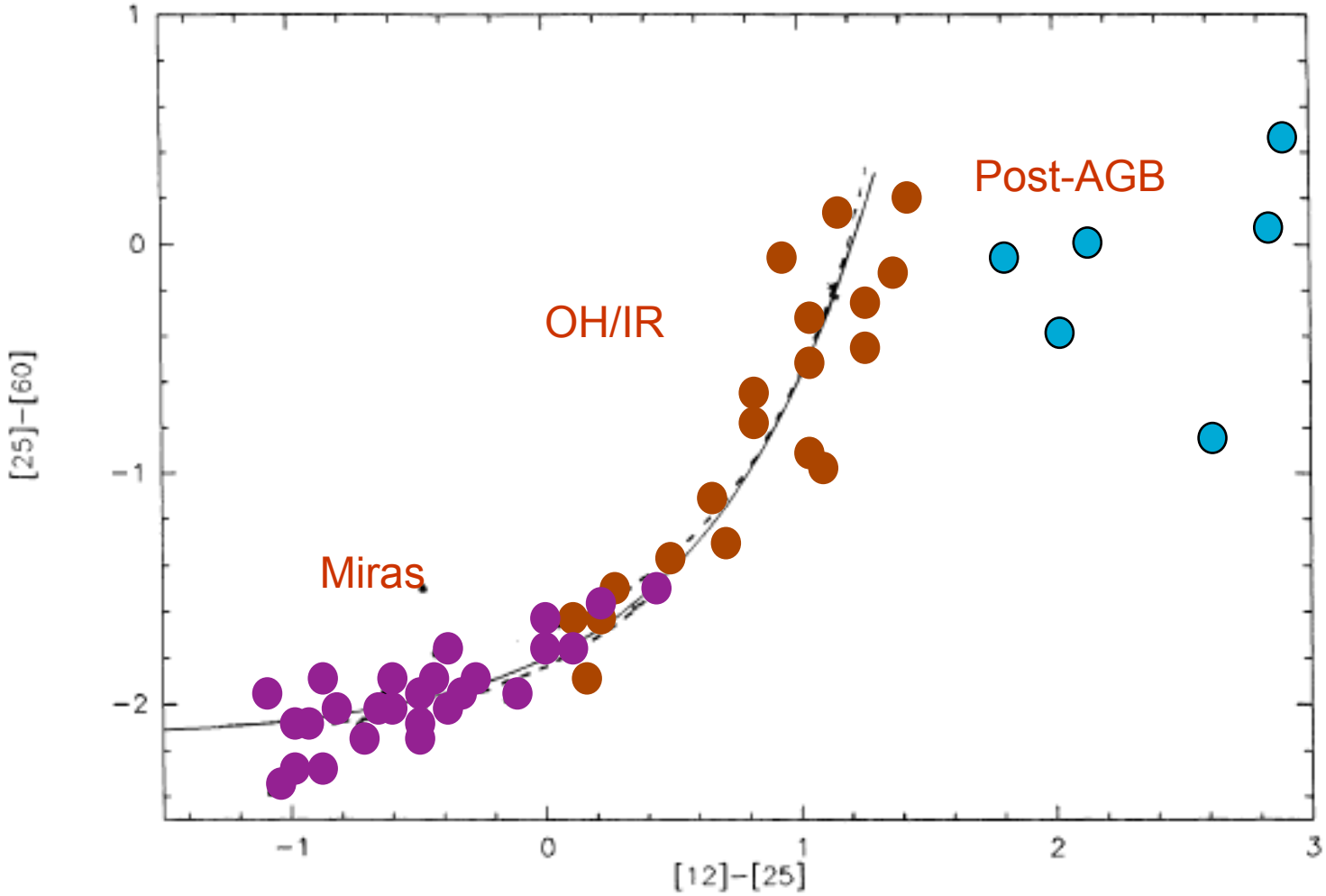
Overview

- Introduction to Asymptotic Giant Branch (AGB) and post-AGB stars
- OH 1612 MHz maser surveys
- OH 1612 MHz maser emission from AGB stars
- Post-AGB stars and water fountains

Late stages of stellar evolution

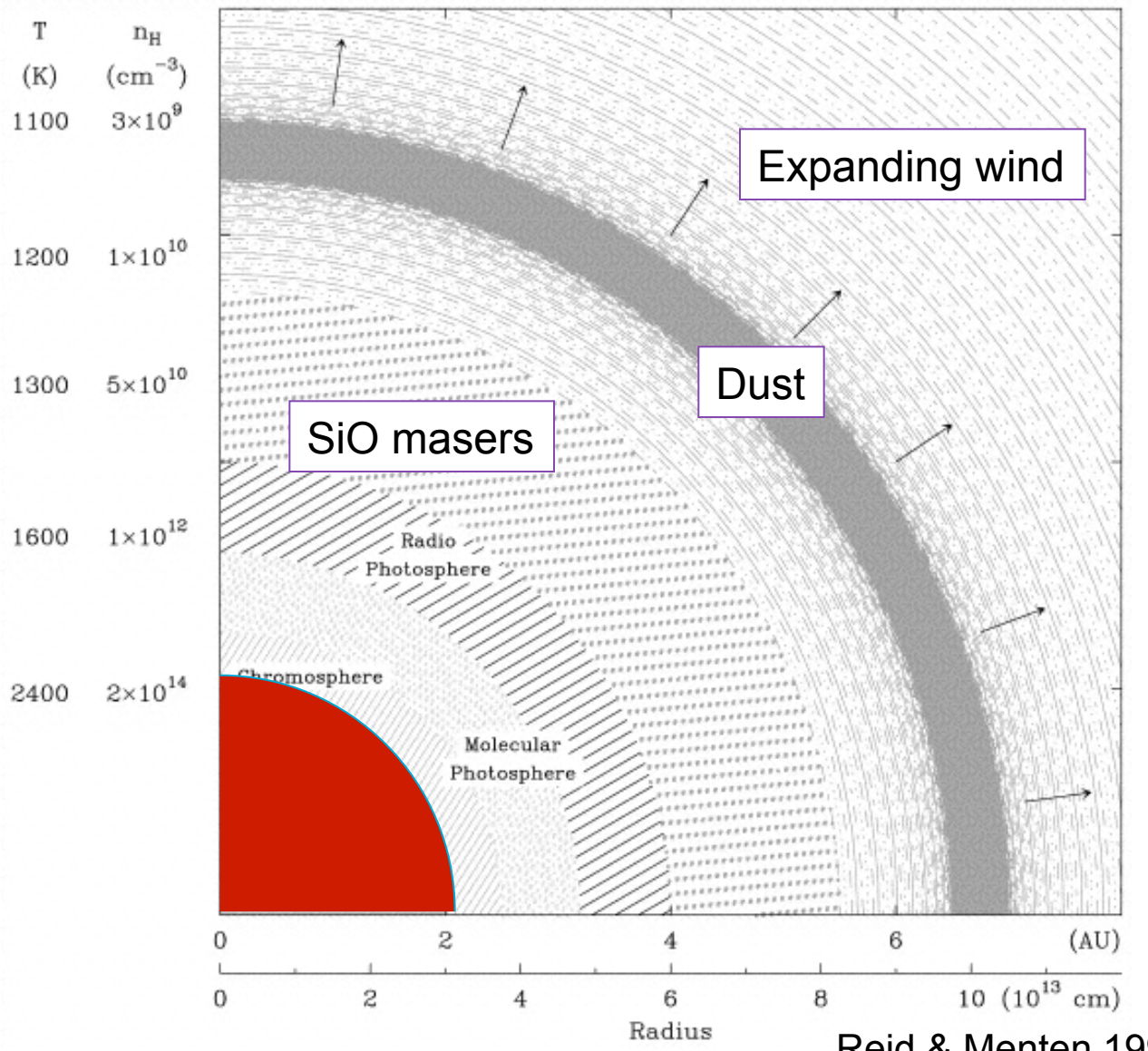


IRAS two-colour diagram



Van der Veen & Habing 1988

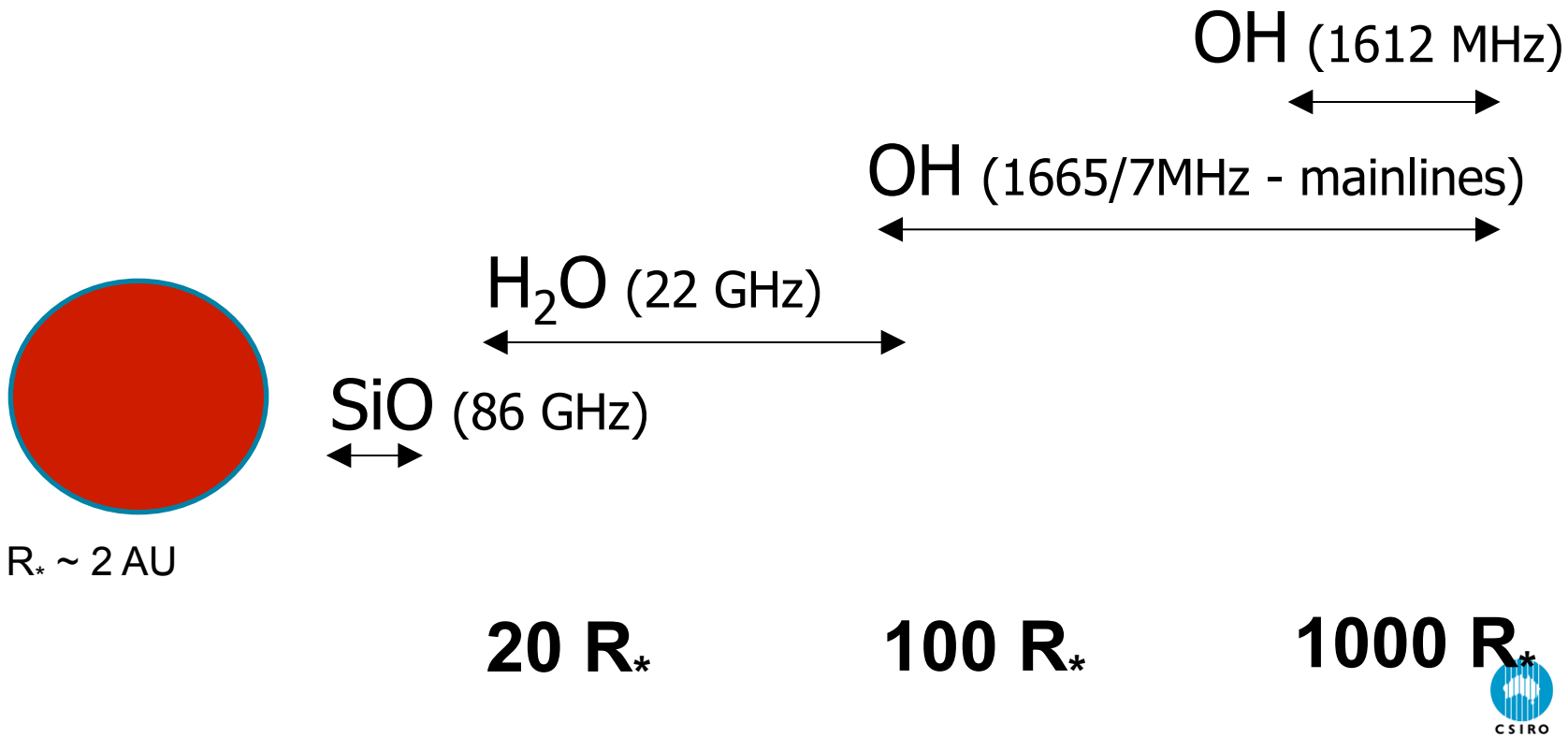
The inner circumstellar envope of an AGB star



Reid & Menten 1997

Masers in AGB stars

For AGB stars, SiO, H_2O and OH masers are detected at different radii in the circumstellar envelopes.



OH 1612 MHz survey of IRAS sources

ASTRONOMY & ASTROPHYSICS
SUPPLEMENT SERIES

Astron. Astrophys. Suppl. Ser. **90**, 327-353 (1991)

OCTOBER II 1991, PAGE 327

1612 MHz OH survey of IRAS point sources
I. Observations made at Dwingeloo, Effelsberg and Parkes

P. te Lintel Hekkert[1,3], J.L. Caswell[2], H.J. Habing[1], R.F. Haynes[2] and R.P. Norris[2]

[1] Sterrewacht Leiden, P.O. Box 9513, 2300 RA Leiden, The Netherlands
[2] CSIRO, Division of Radiophysics, P.O. Box 76, Epping, NSW 2121, Australia
[3] Presently at: Mt Stromlo Observatory, Private Bag, Weston P.O., ACT 2611, Australia

Received May 16, 1990; accepted March 1991

Abstract. — We have observed 2703 IRAS point sources at the 1612 MHz transition of OH and detected 738 OH/IR stars; 597 of these are new discoveries. The IRAS sources were selected on the basis of their infrared colours using the 12, 25 and 60 μm fluxes. The survey is 70% complete for IRAS point sources in the southern hemisphere ($\delta < -10^{\circ}$), with infrared colours: $\log\left(f_{25\ \mu m}/f_{12\ \mu m}\right) > -0.2$ and $\log\left(f_{60\ \mu m}/f_{12\ \mu m}\right) < 0.6$ and having a 12 μm flux exceeding 3 Jy. The majority of the OH profiles show twin peak maser features, characteristic of emission from an expanding circumstellar shell. The detection statistics of the survey are discussed. Detailed statistical analyses of the OH/IR star sample are made in a subsequent paper.

Observed 2703 IRAS sources at 1612 MHz
738 detections of OH 1612 MHz maser emission
Of these about 95% showed a doubled-peaked spectrum

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ATCA/VLA OH 1612 MHz survey of the Galactic Plane

OH 1612 MHz 'Blind' survey of the Galactic plane

$|b| < 3$ degrees

$|l| < 45$ degrees

$|v| < 350$ km/s

Number of fields searched = 2414

Sevenster, Chapman, van Langevelde, Killeen, Habing: 1997 - 2001

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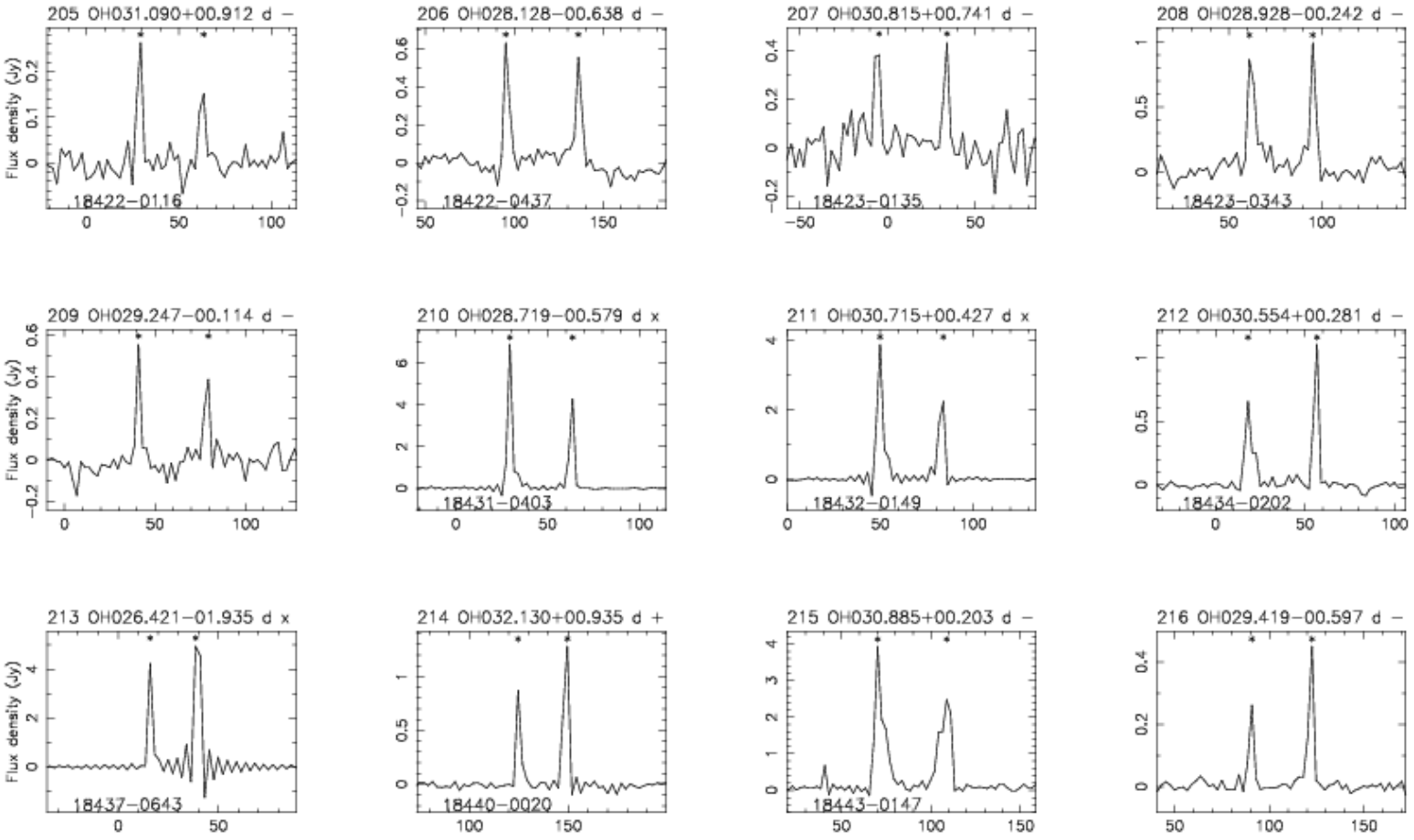
Survey results: 766 detections



661/766 detections had double-peaked spectra

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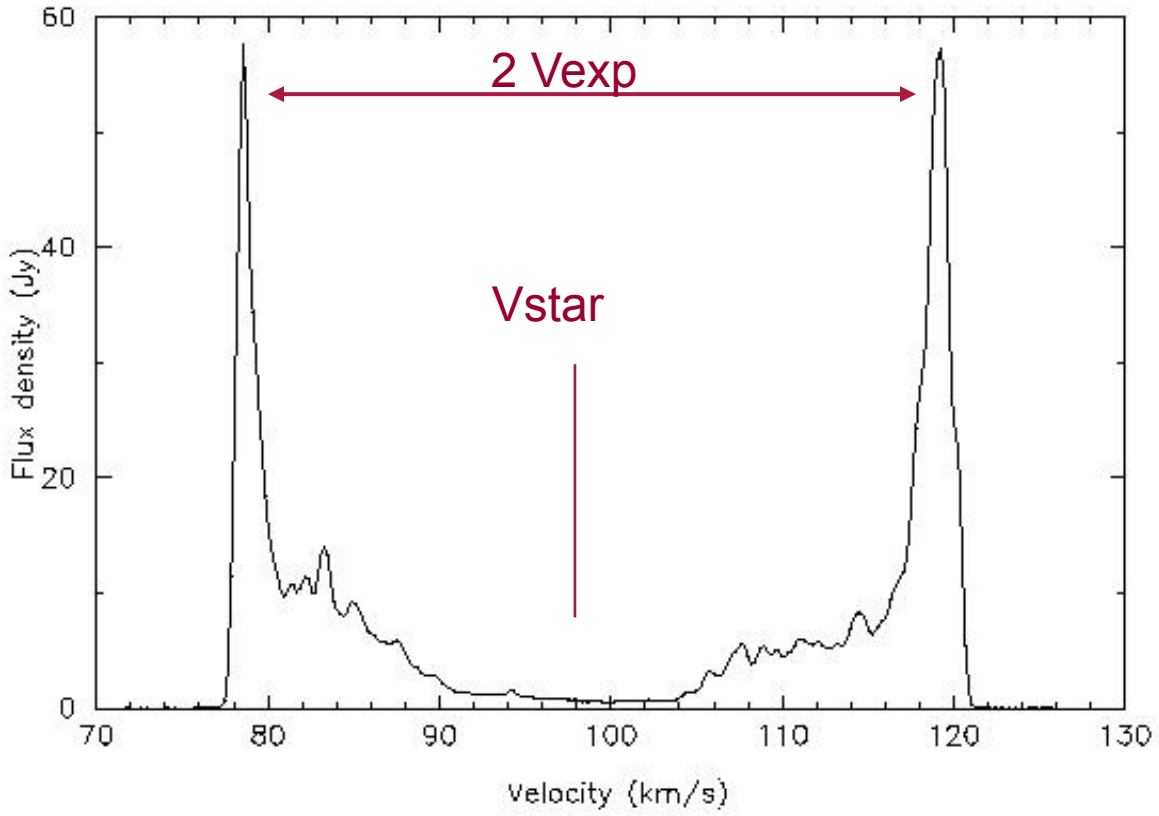
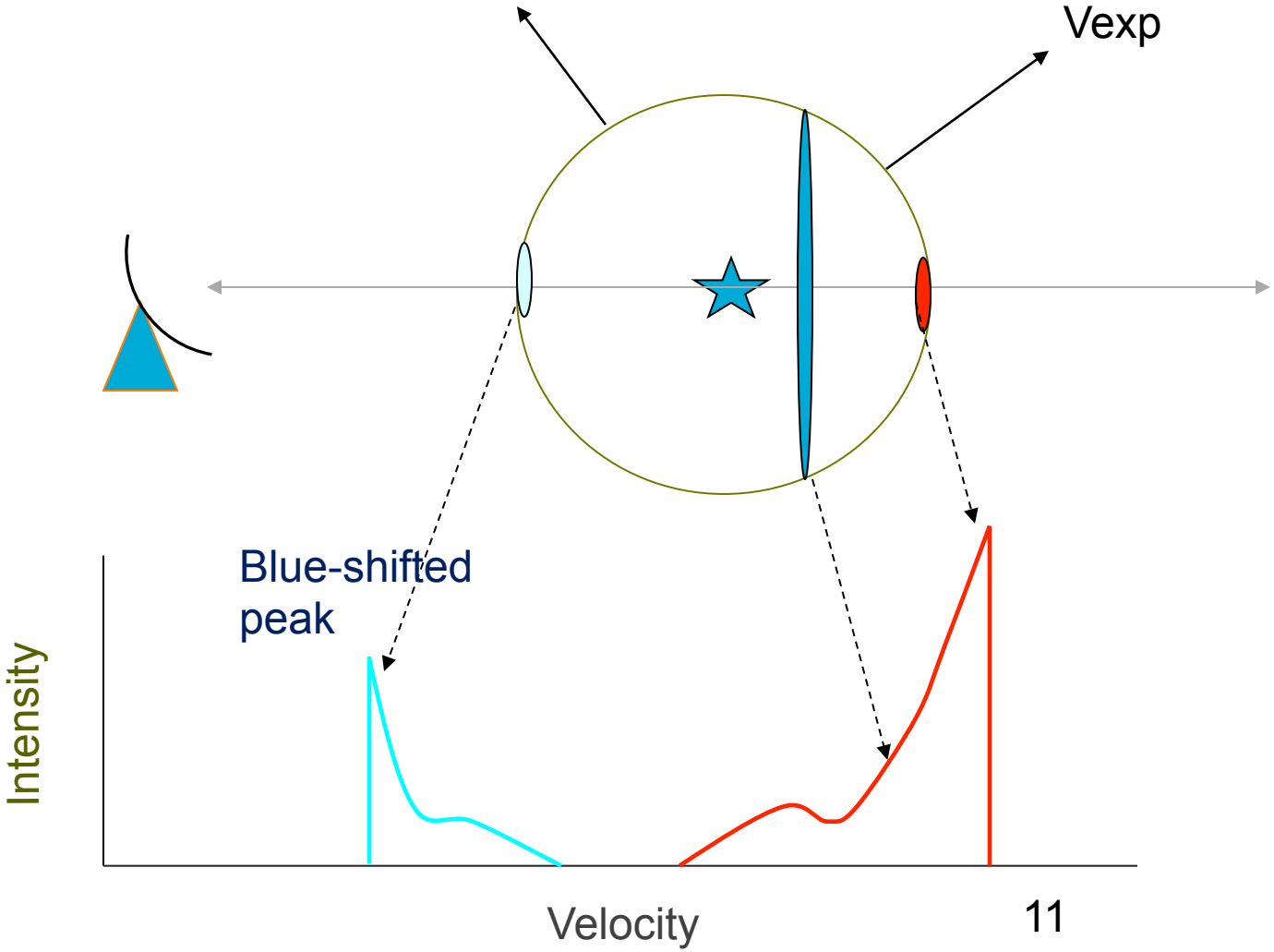
Maser emission from AGB stars

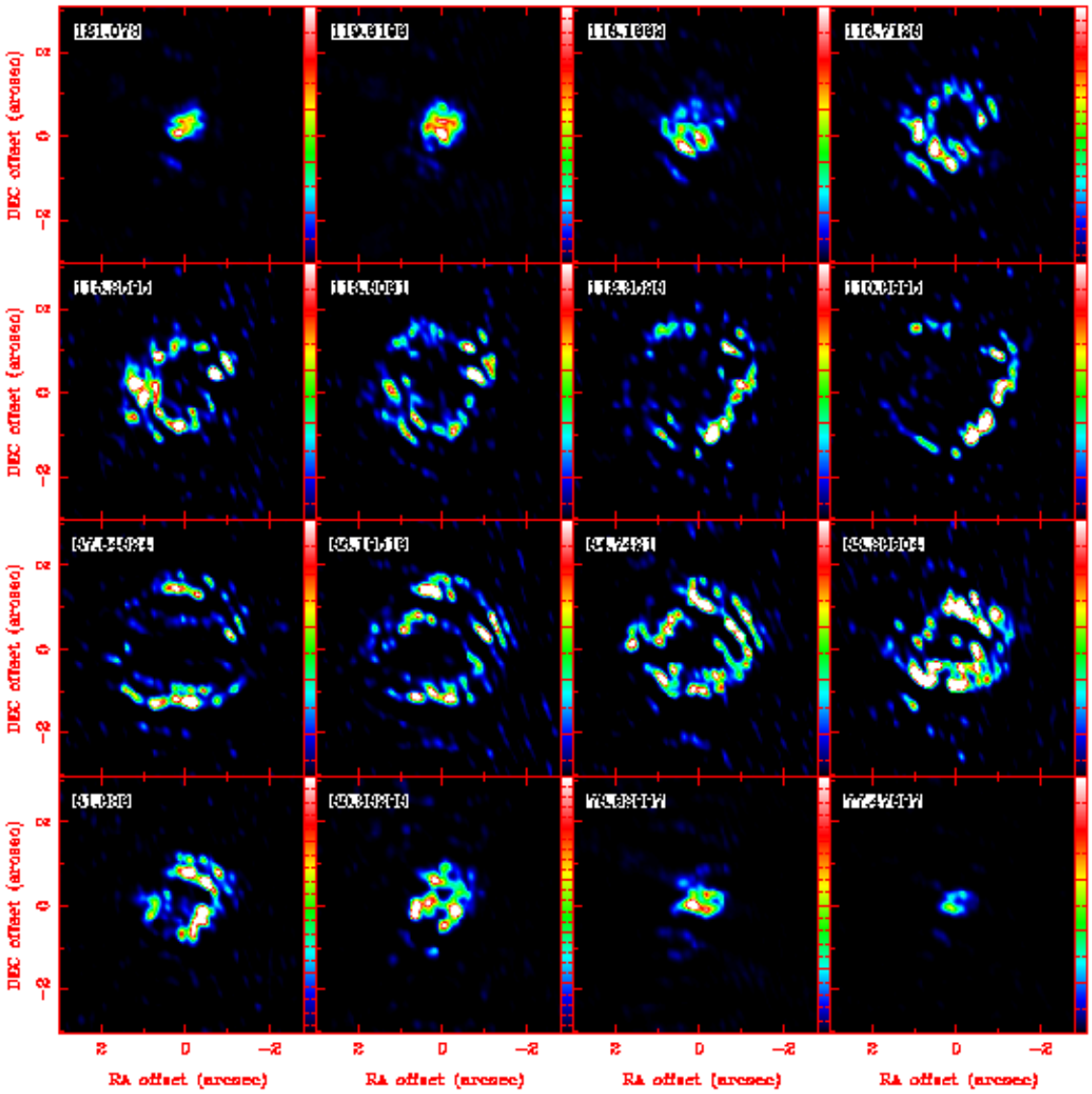
- Strongest maser emission from the OH 1612 MHz transition.
- About 2/3 of ~ 1600 detections from Parkes and ATCA



OH 1612 MHz maser geometry



OH 1612 MHz – the outer circumstellar shell



OH 1612 MHz masers:

Located at > 100 R_*

Spherically symmetric

Little/no acceleration

Little/no polarization

Saturated

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Maser emission from post-AGB stars

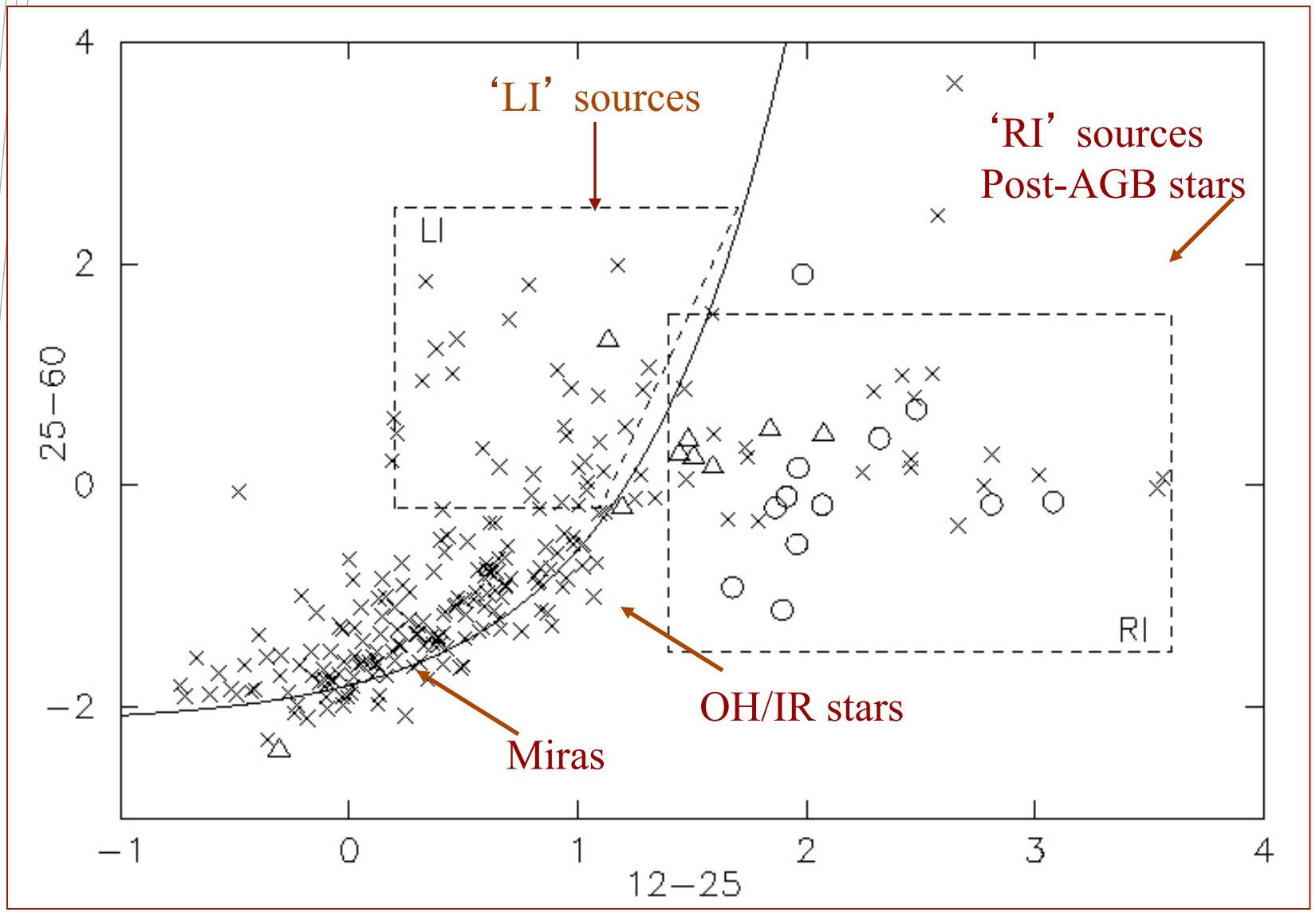
- 85 evolved stars selected from the ATCA/ VLA OH 1612 MHz survey.

With:

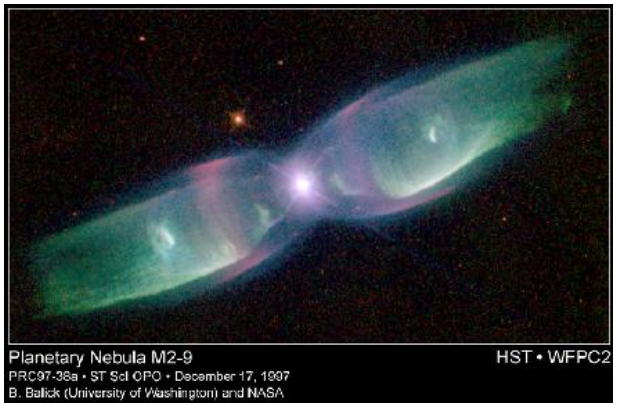
- IRAS and MSX colours associated with likely post-AGB stars

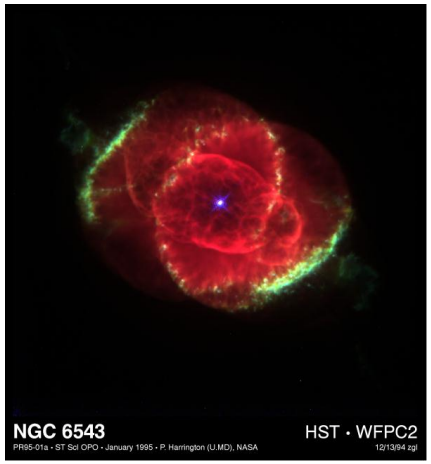
To study the OH, H_2O maser properties of post-AGB stars, including polarisation.

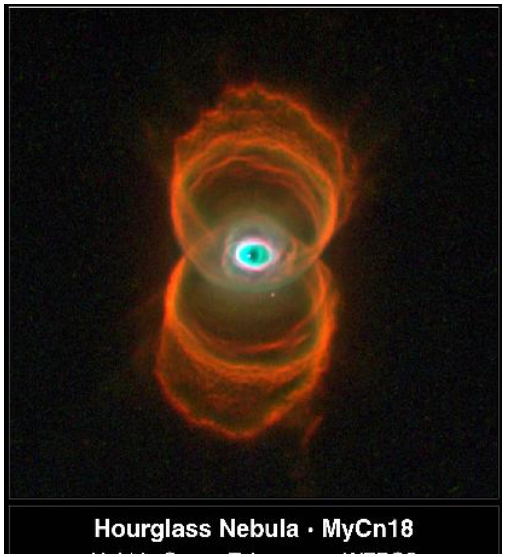
IRAS colours for ATCA/VLA survey sources (766 detections)



Planetary nebulae morphologies







About 50% of planetary nebulae are non-spherical: Why?

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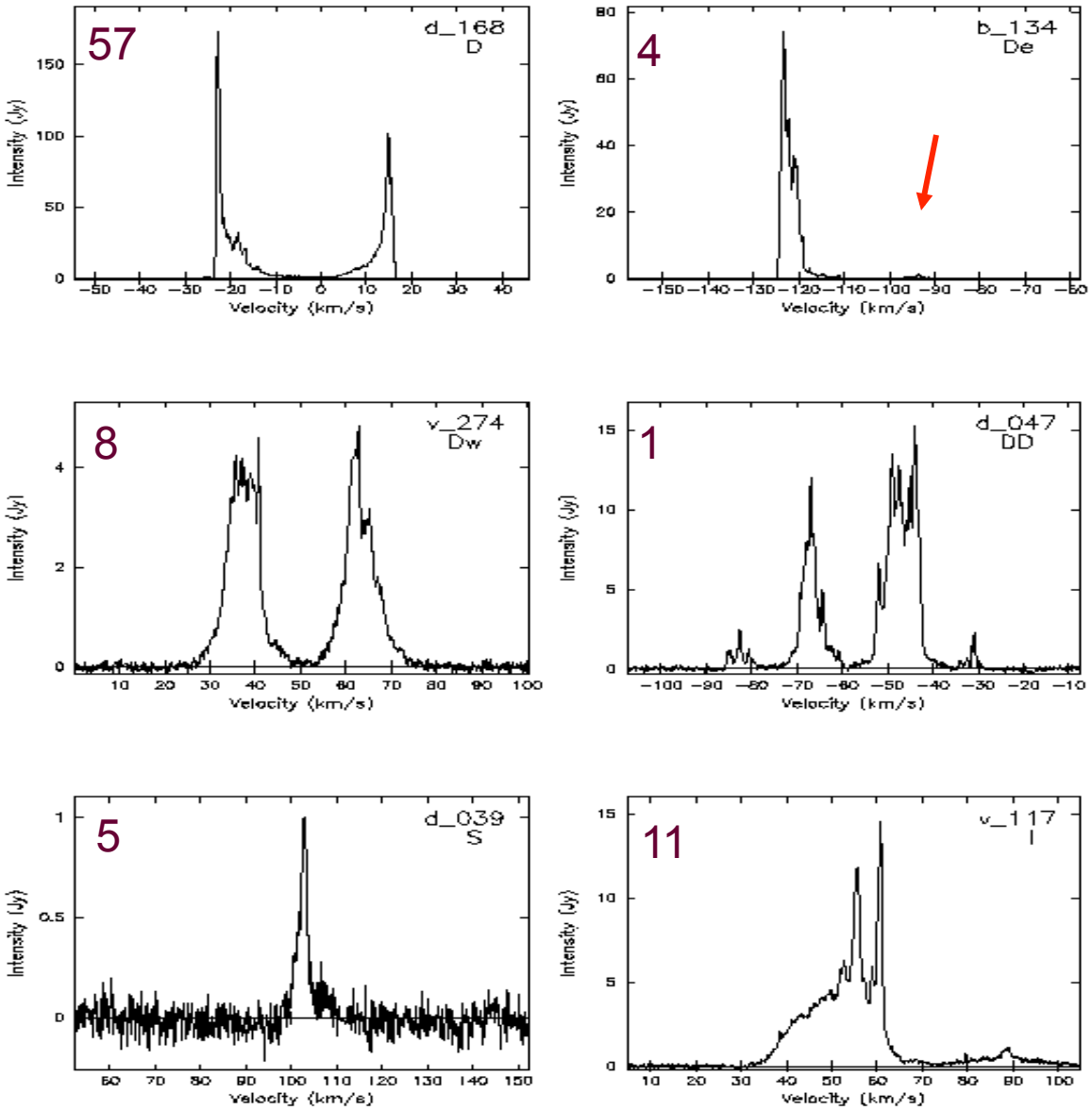
OH 1612 MHz spectral profiles for post-AGB stars (Parkes data)



Deacon sample:

2/3 of the stars
In this sample have standard double-peaked OH 1612 MHz profiles.

Deacon, Chapman & Green 2003

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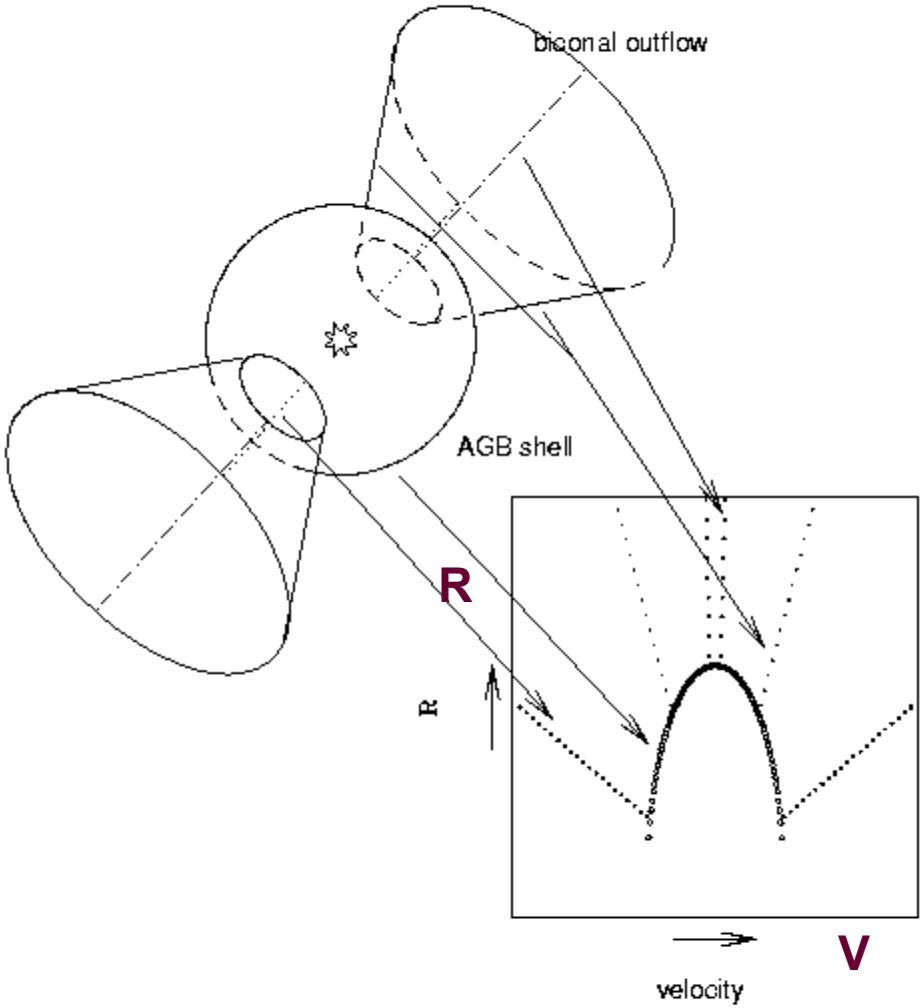
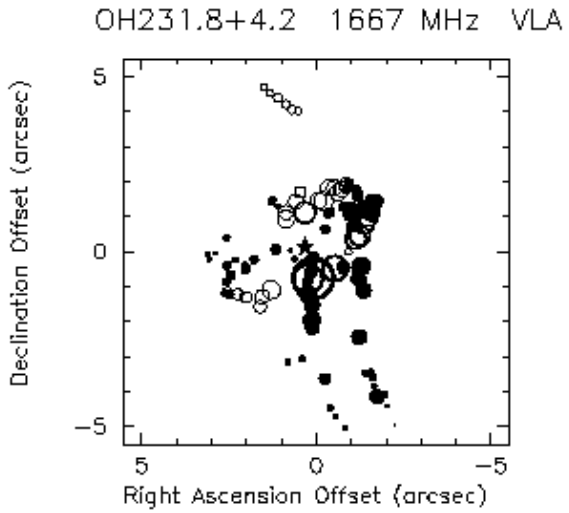
Bipolar outflows: a 2-wind model

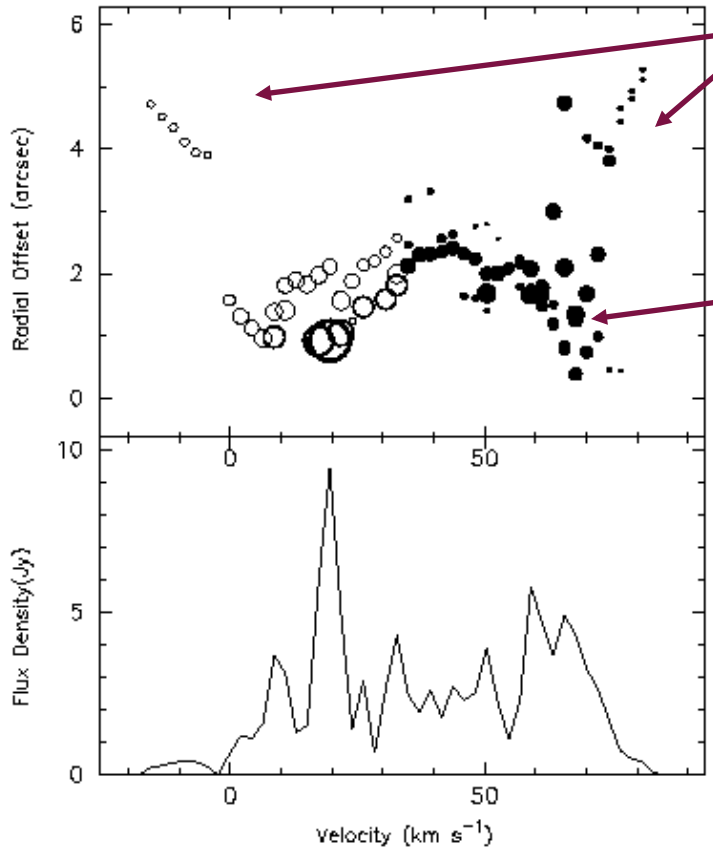


i) Remnant AGB wind:
Vexp = constant
Rshell = constant

ii) Faster bipolar outflow:
$V \propto R$

OH 231.8+4.2
Calabash nebula





Bipolar outflow: Vobs < 55 km/s

AGB wind: Vexp ~ 35 km/s

Zijlstra, Chapman, et al. 2001

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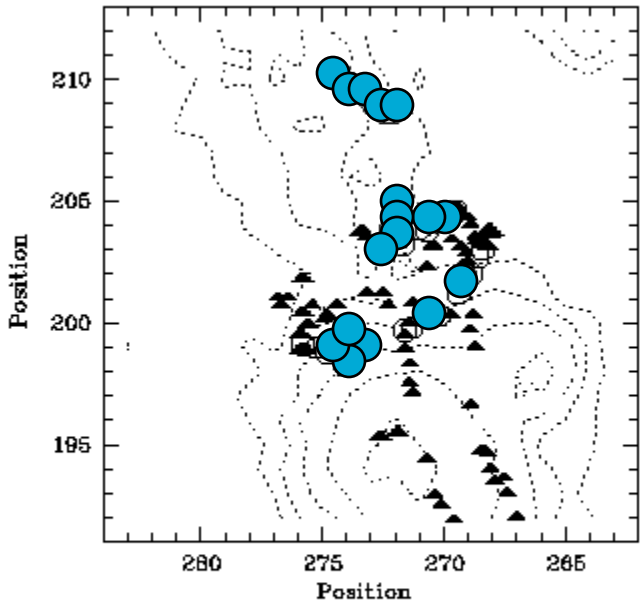
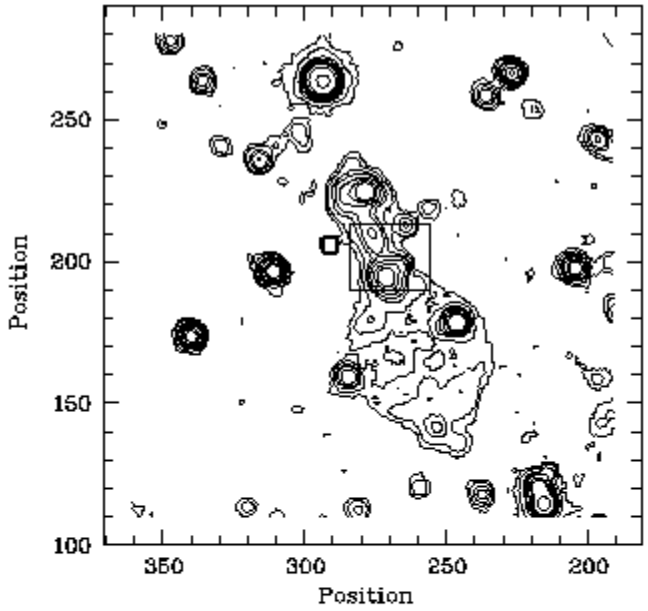
OH 231.8+4.2



OH 1667 MHz masers
and central Hα emission

blue-shifted

red-shifted



Hα emission

Zijlstra, Chapman et al. 2001

H_2O maser observations of Deacon sample

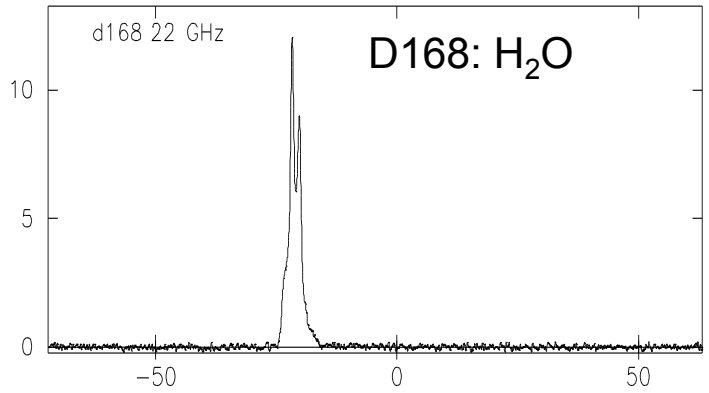
- 21 H_2O maser detections

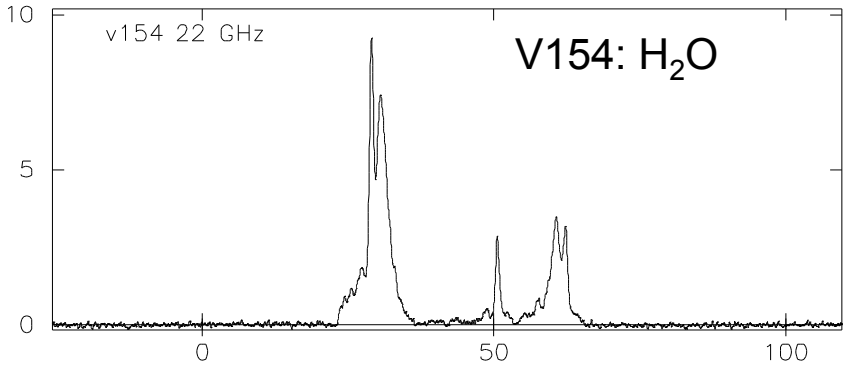
Two distinct types of sources:

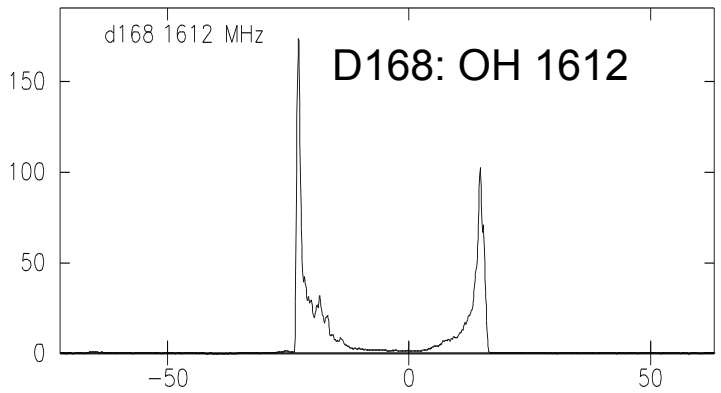
1) Massive AGB stars with ‘regular’ water maser profiles (15 sources)

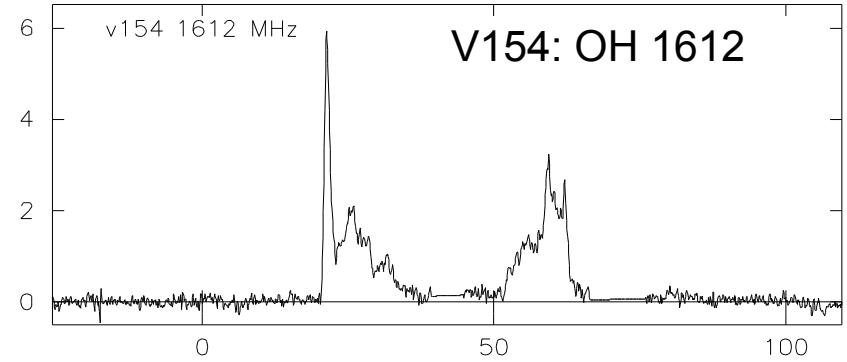
2) More evolved stars with high velocity water maser emission (5 sources)

Two examples: d168 (IRAS 17004-4119) and v154 (IRAS 18327-0715)







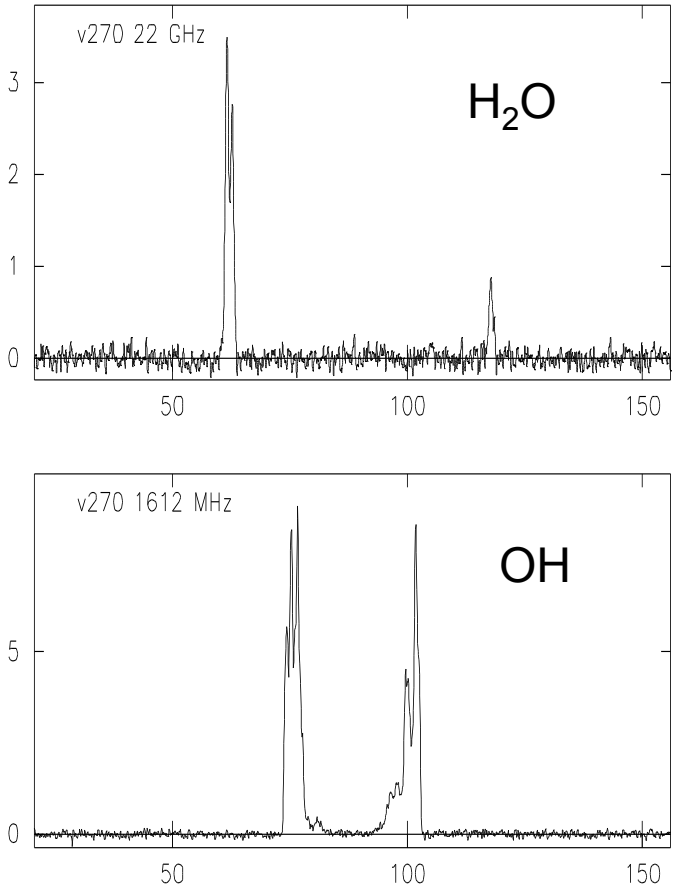


OH and water maser emission from massive AGB stars

Water fountains: Post-AGB stars with high velocity water emission:

- ΔV (H2O) > ΔV (OH 1612)
- 5/85 dections for full sample
- 4/55 detections excluding the LI sources
- 2 previously known
- 3 new detections

V270 (IRAS 18596+0315)



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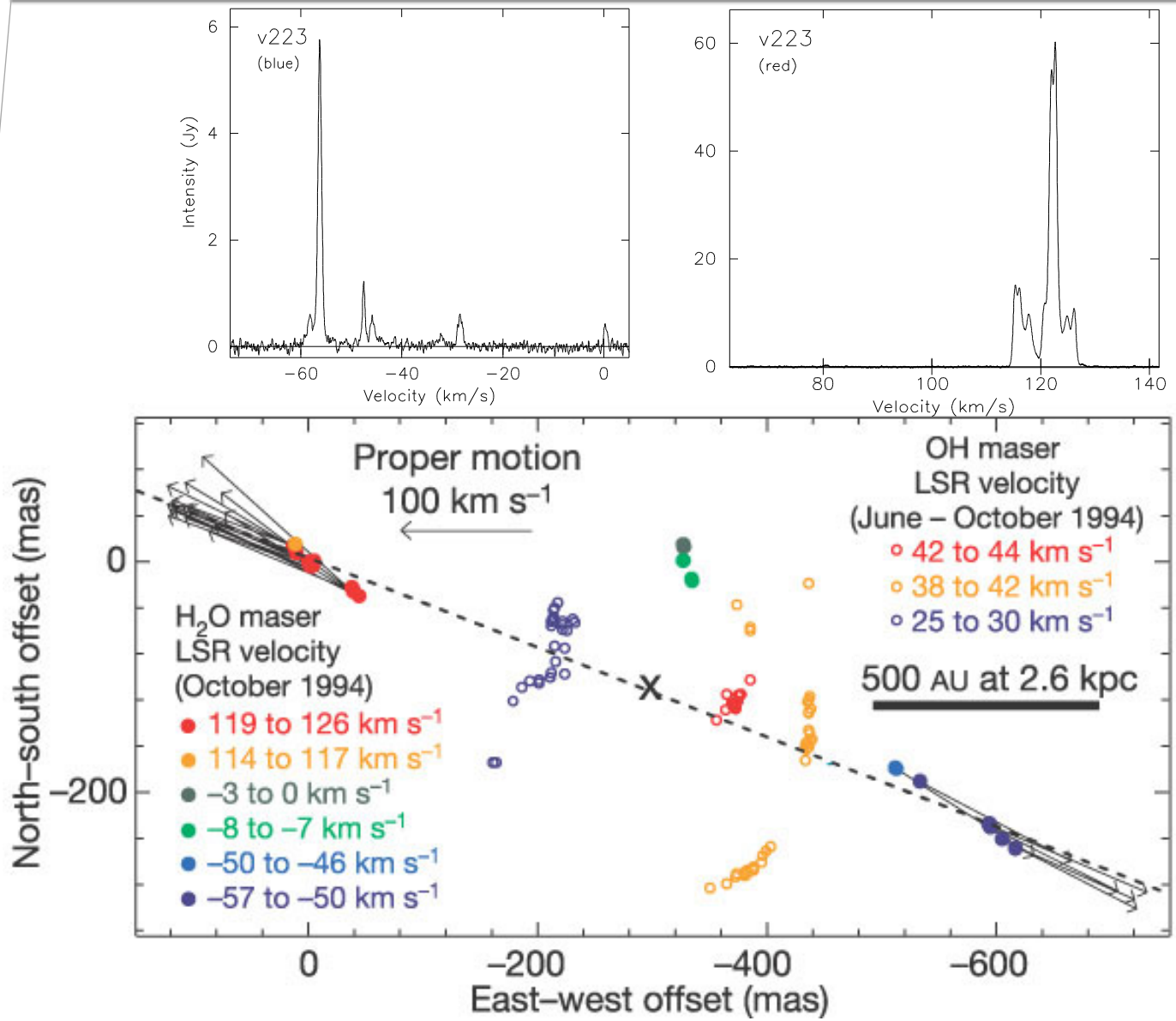
V223 (W43A: Water fountain source)

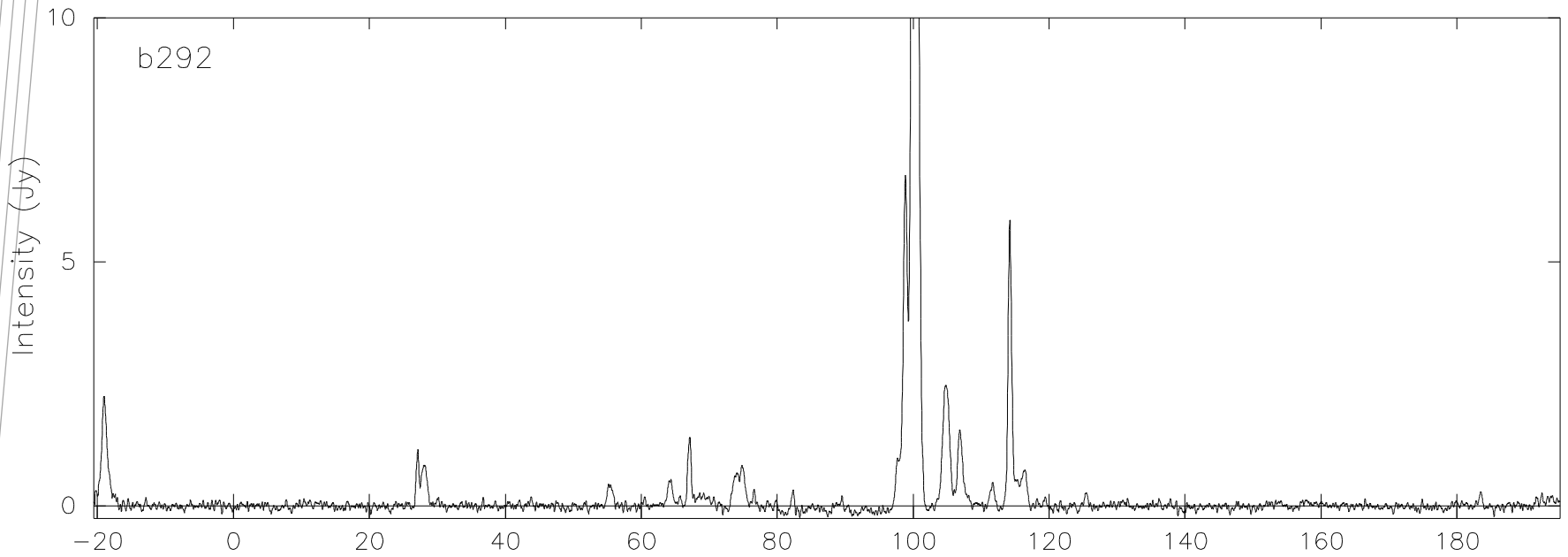


Imai et al. 2005

B292 (IRAS 18043-2116)
A young post-AGB star

ΔV (H_2O) > 200 km s^{-1}, ΔV (OH) ~ 33 km s^{-1}

OH 1720 MHz emission previously detected



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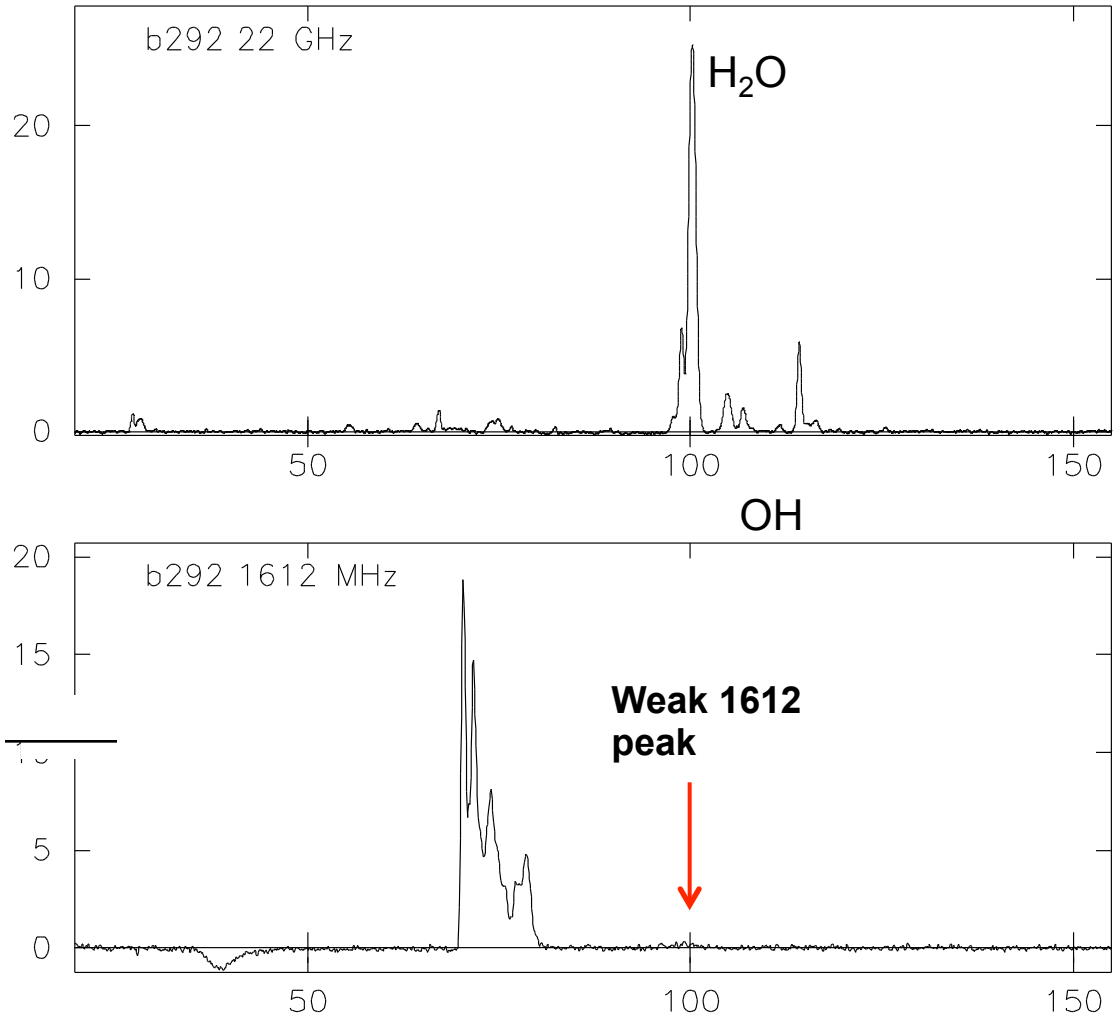
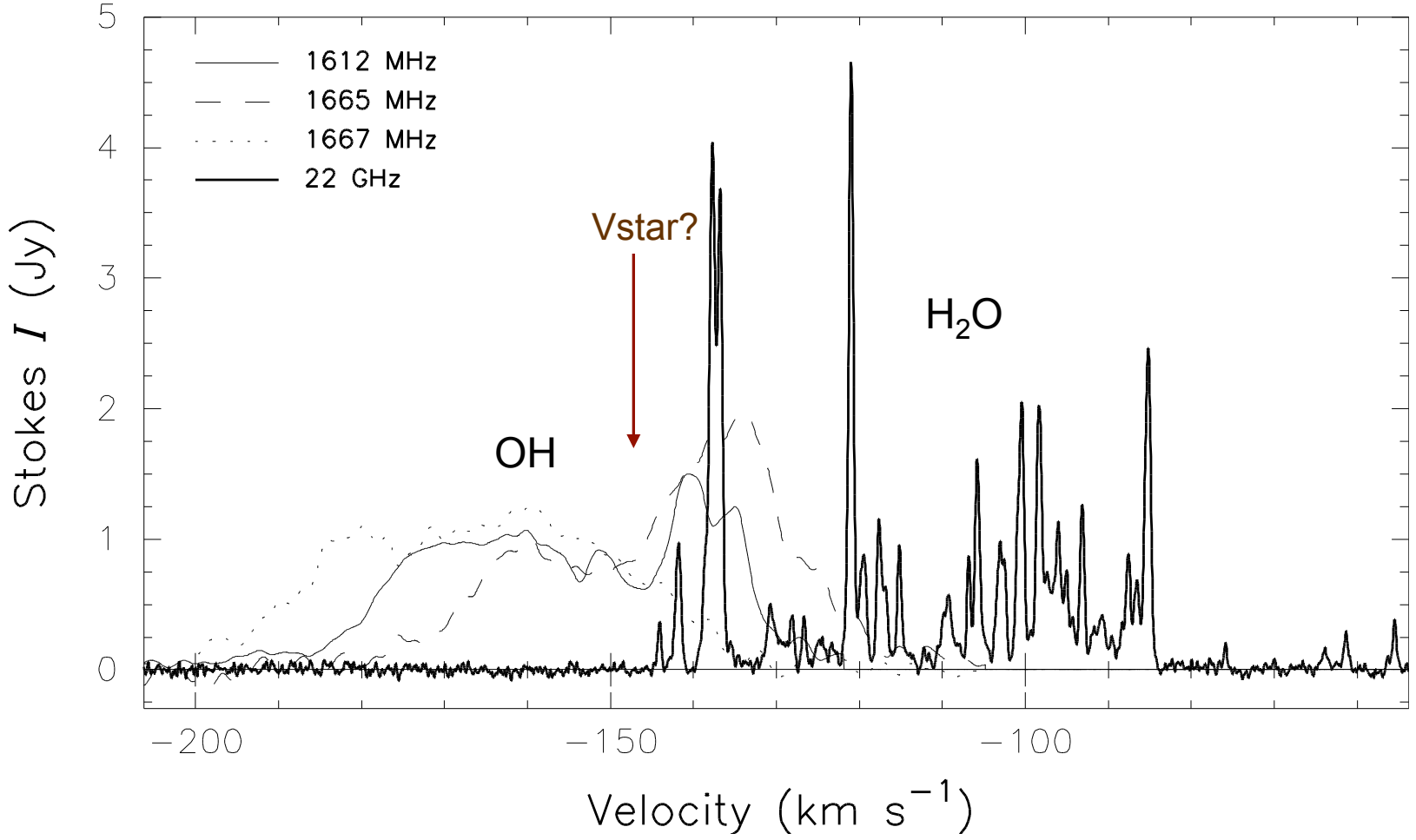
B292 : Inner spectrum



4/5 of high-velocity water sources are stronger on the red-shifted side.

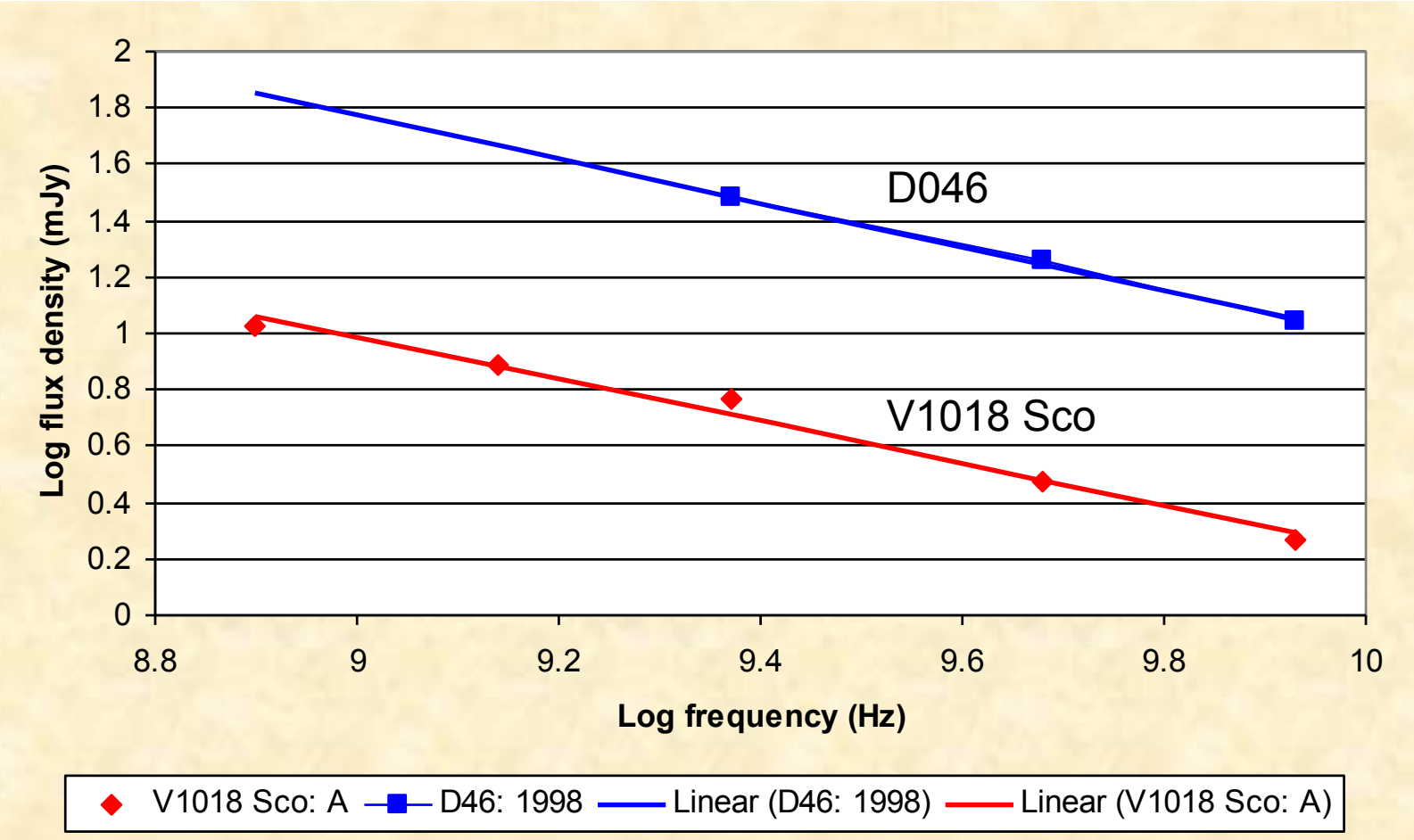
IRAS 15445-5449 (D46)

An evolved post-AGB star with a one-sided water jet

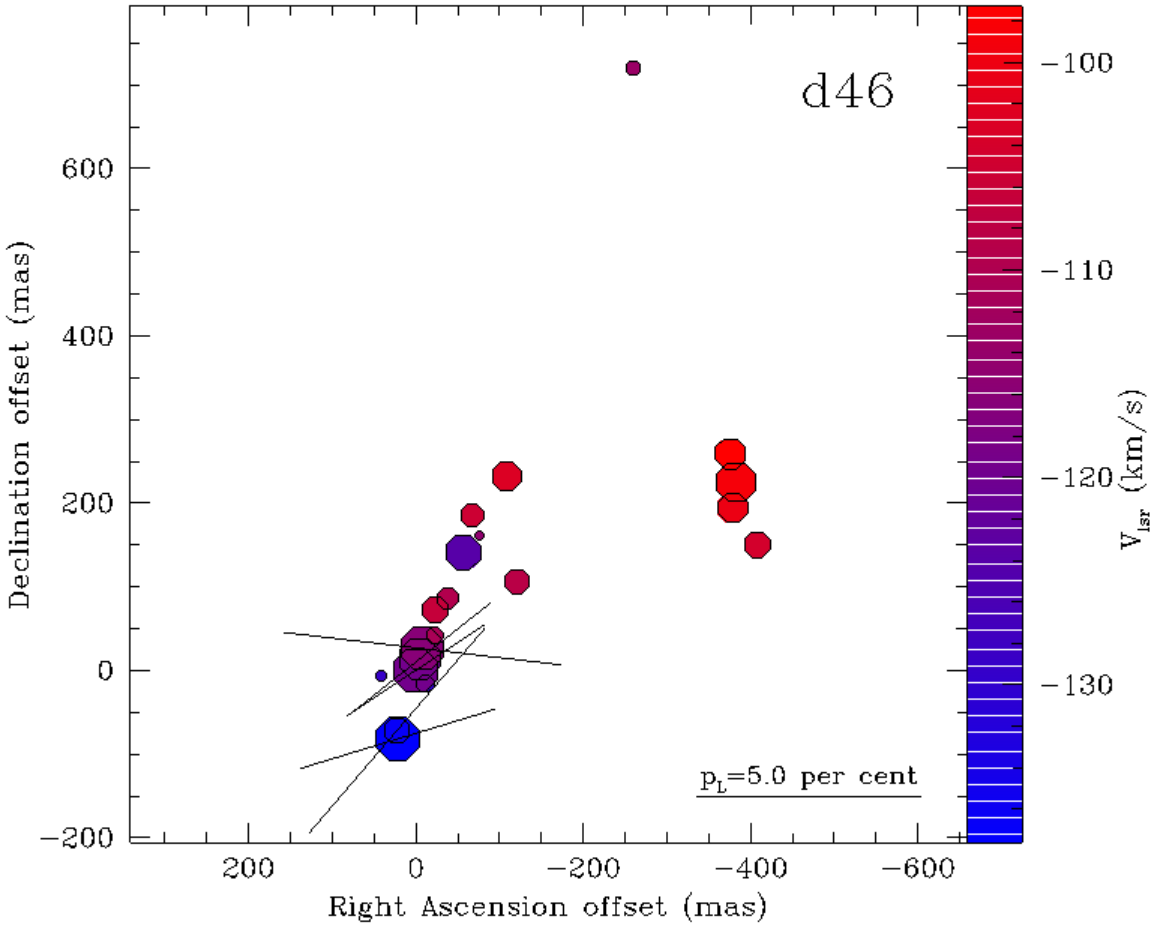


Non-thermal radio continuum from V1018 Sco and D46

Slope: α = -0.8



Water masers in IRAS 15445-5449 (d46)



Linear polarisation indicates a magnetic field direction along outflow axis.

Perez-Sanchez,Vlemmings & Chapman 2011

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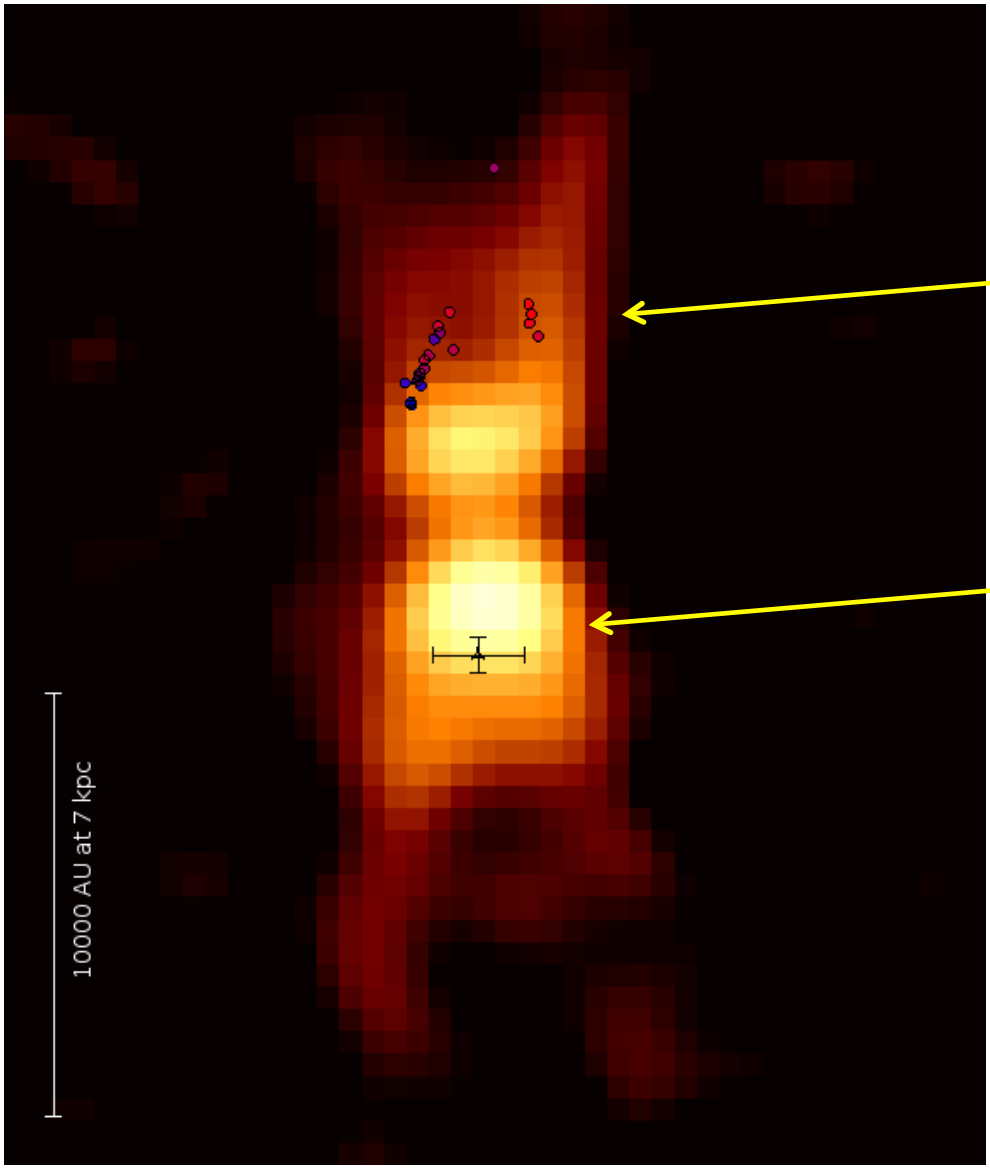
Water masers, mid-infrared and radio continuum from d46



Water masers

Radio continuum

Mid IR: Lagadec et al. 2011

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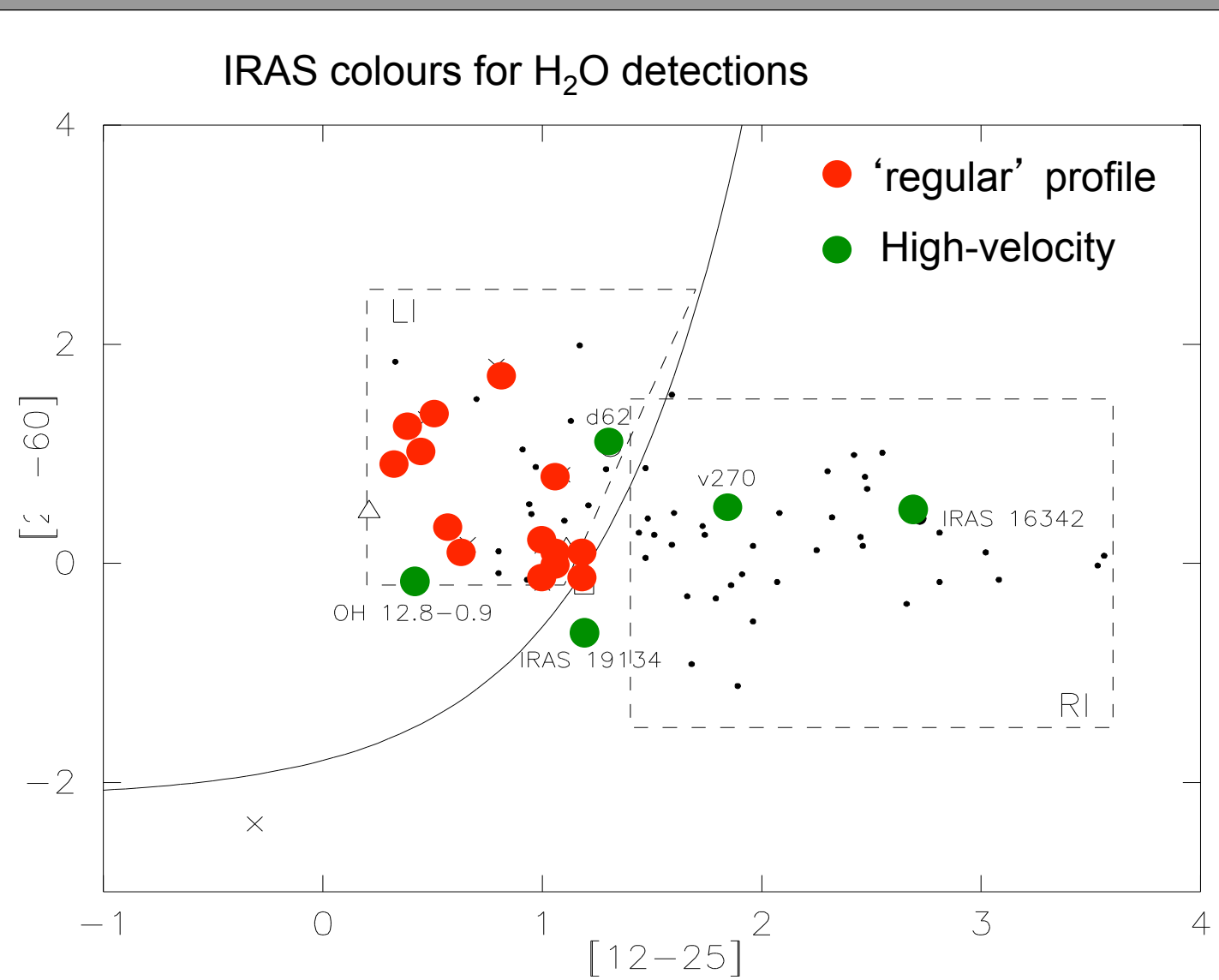
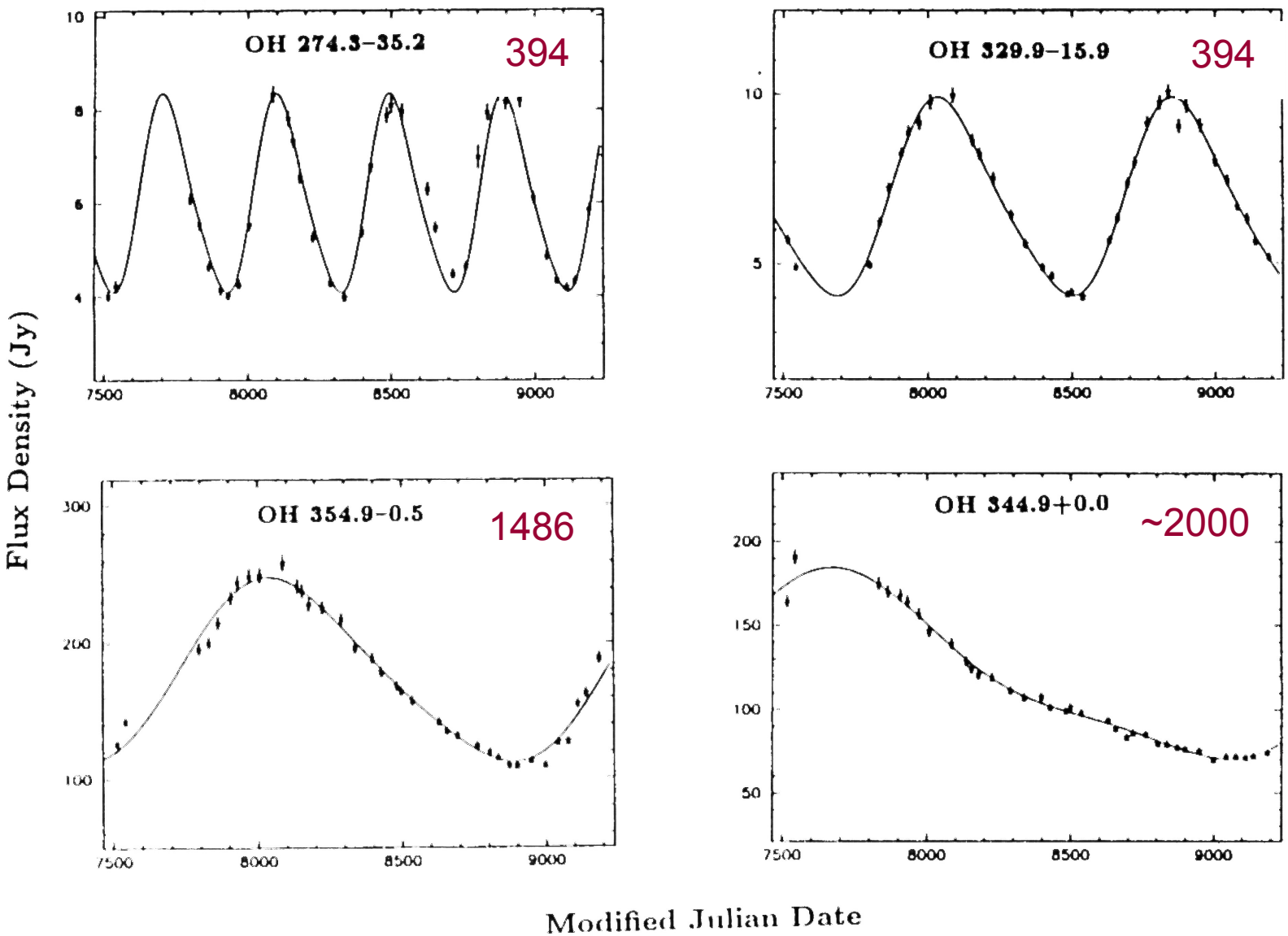
Bipolar outflows from evolved stars

- Bipolar outflows are associated with post-AGB stars.
- For the ‘water fountain sources’, collimated maser ‘jets’ extend beyond the OH masing region.
- For bipolar sources the OH and H_2O masers are polarised and are likely’ to be magnetically collimated.
- Synchroton radio continuum emission detected in some cases.
- H_2O and continuum from shocked wind-wind interactions.
- Bipolarity is (largely) driven by magnetic fields.

Thank you!


IRAS colours for H_2O detections
‘regular’ profile
High-velocity
LI
RI
d62
v270
IRAS 16342
OH 12.8−0.9
IRAS 19134
[12−25]
[25−60]
4
2
0
−2
−1
0
1
2
3
4

OH 1612 MHz light curves: saturated masers



MSX: High-velocity sources