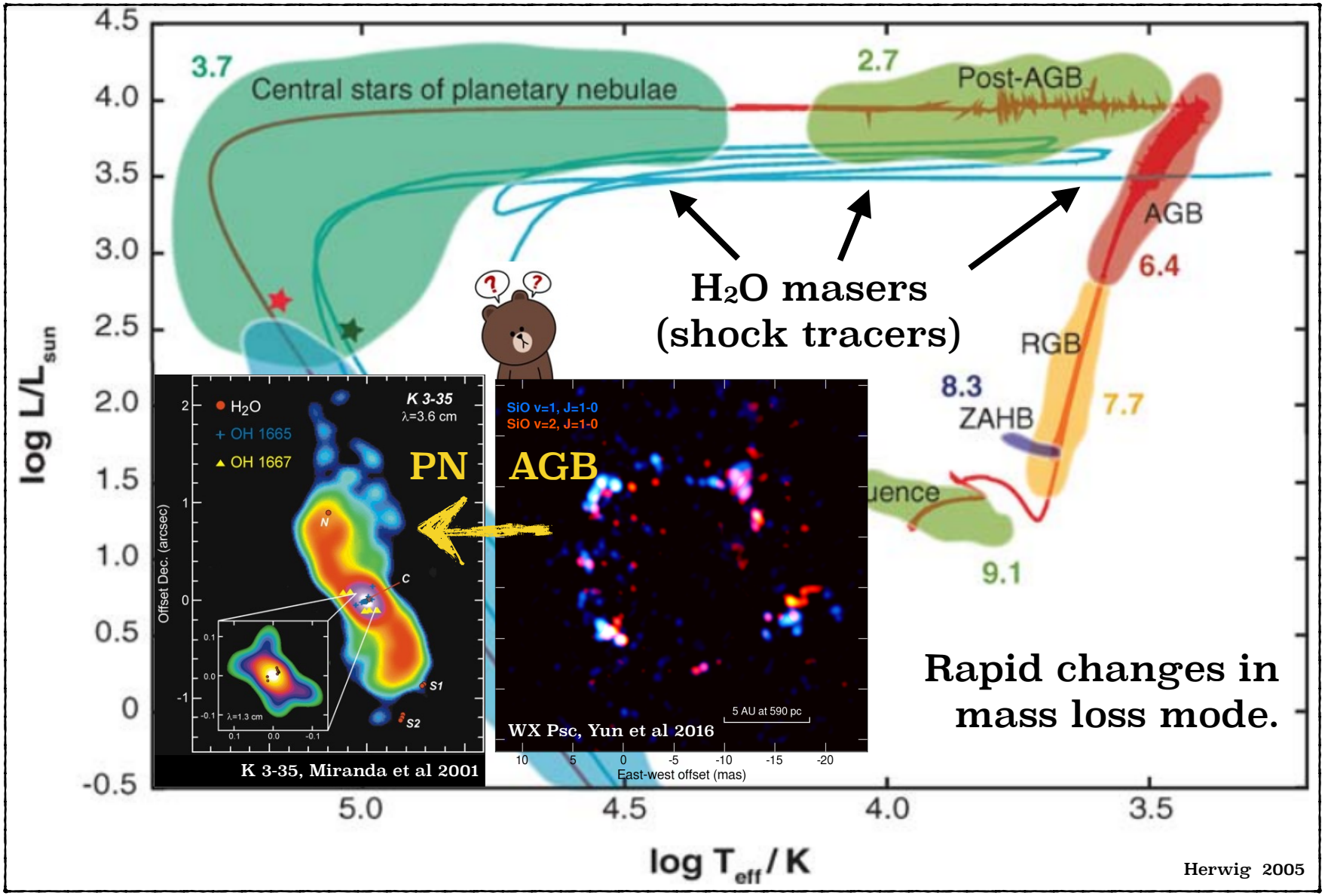
2018 October 10
14th EVN Symposium

XKCD: Time (frame 2395)
http://xkcd.com/1190/

Short-lived episodic outflow in a water fountain star

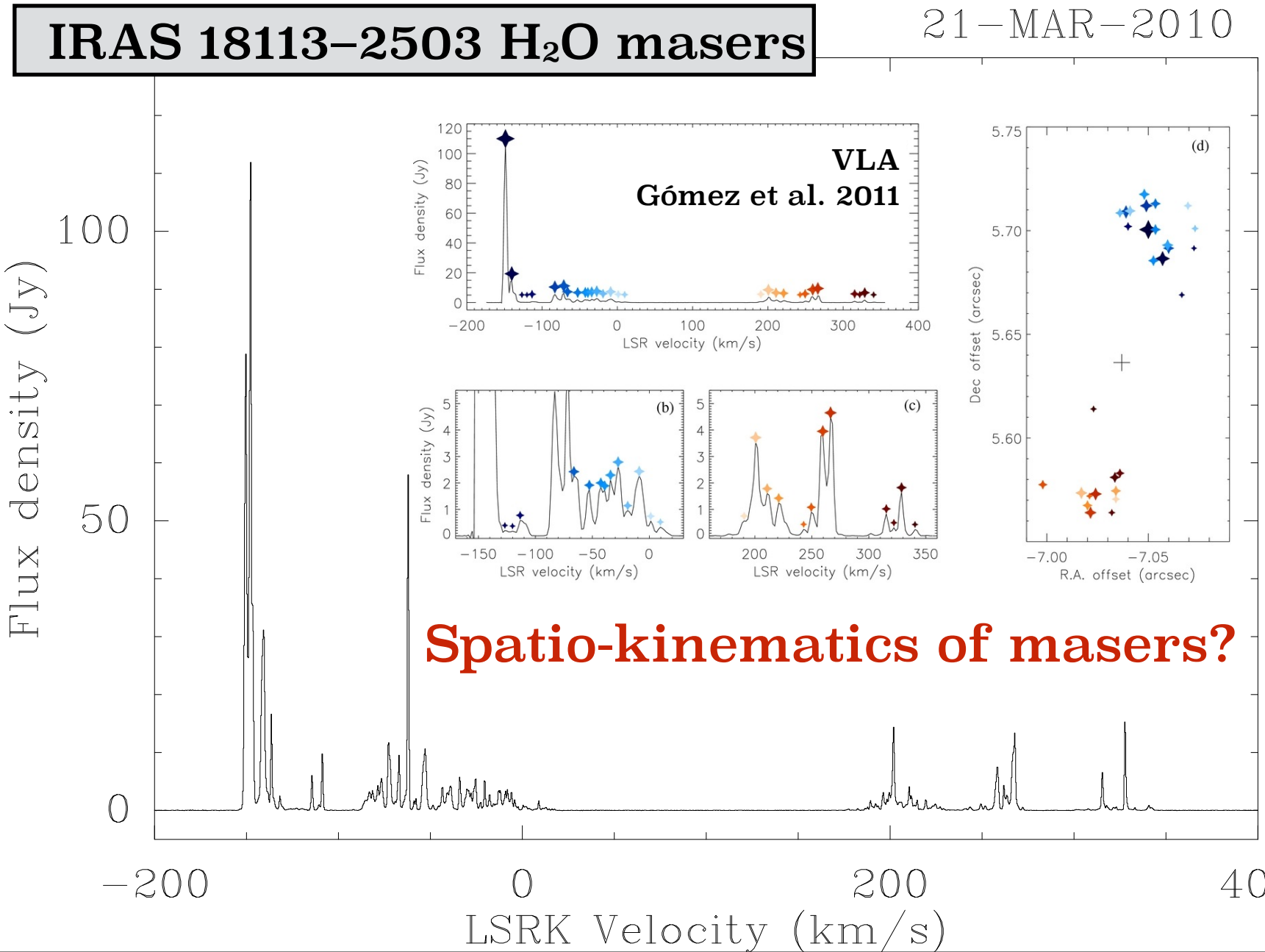
Ross Burns (JIVE, Dwingeloo), on behalf of Gabor Orosz (XAO, Urumqi / UTAS, Hobart)

Jose F. Gomez, Hiroshi Imai, Daniel Tafoya, Jose M. Torrelles, Pau Frau, Martin A. Guerrero, Luis F. Miranda, Miguel A. Perez-Torres, Gerardo Ramos-Larios, J. Ricardo Rizzo, Olga Suarez, Lucero Uscanga

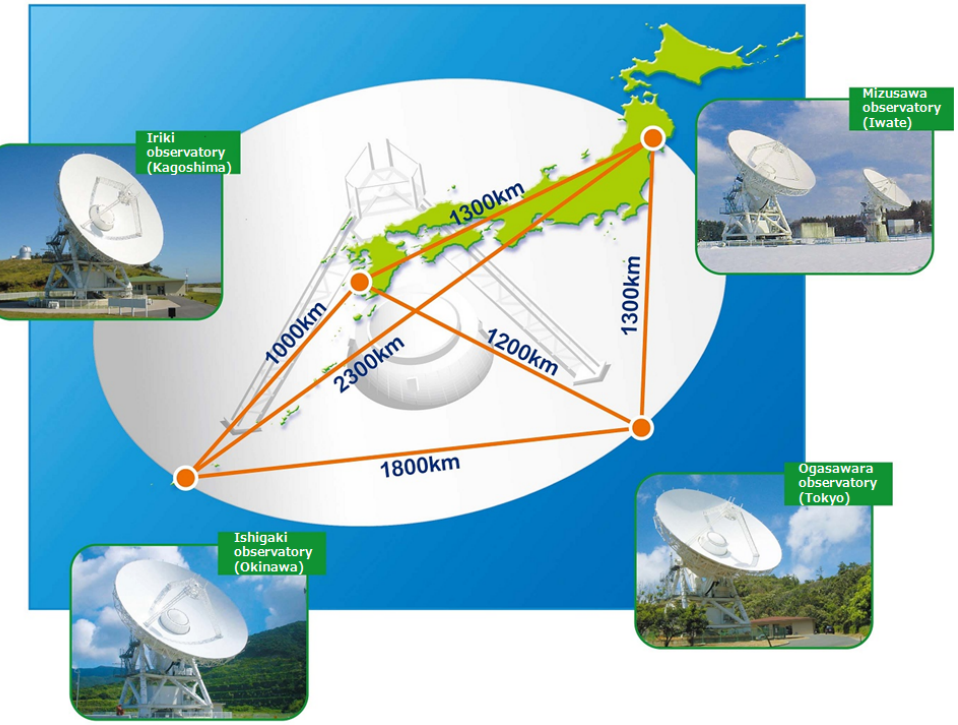


Asymmetric Planetary Nebulae

Water fountain star: IRAS 18113–2503



Multi-epoch VLBI H_2O maser observations

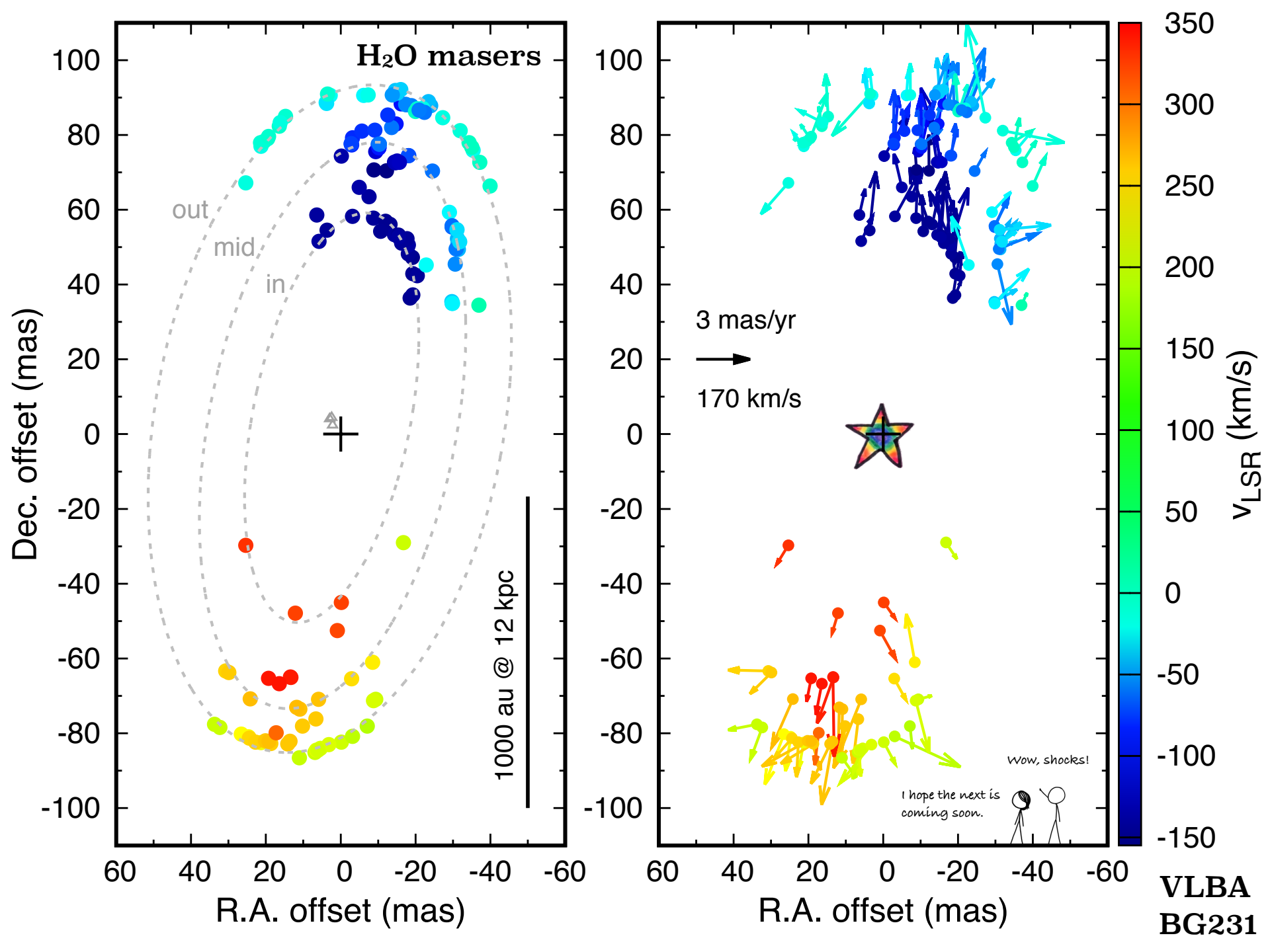


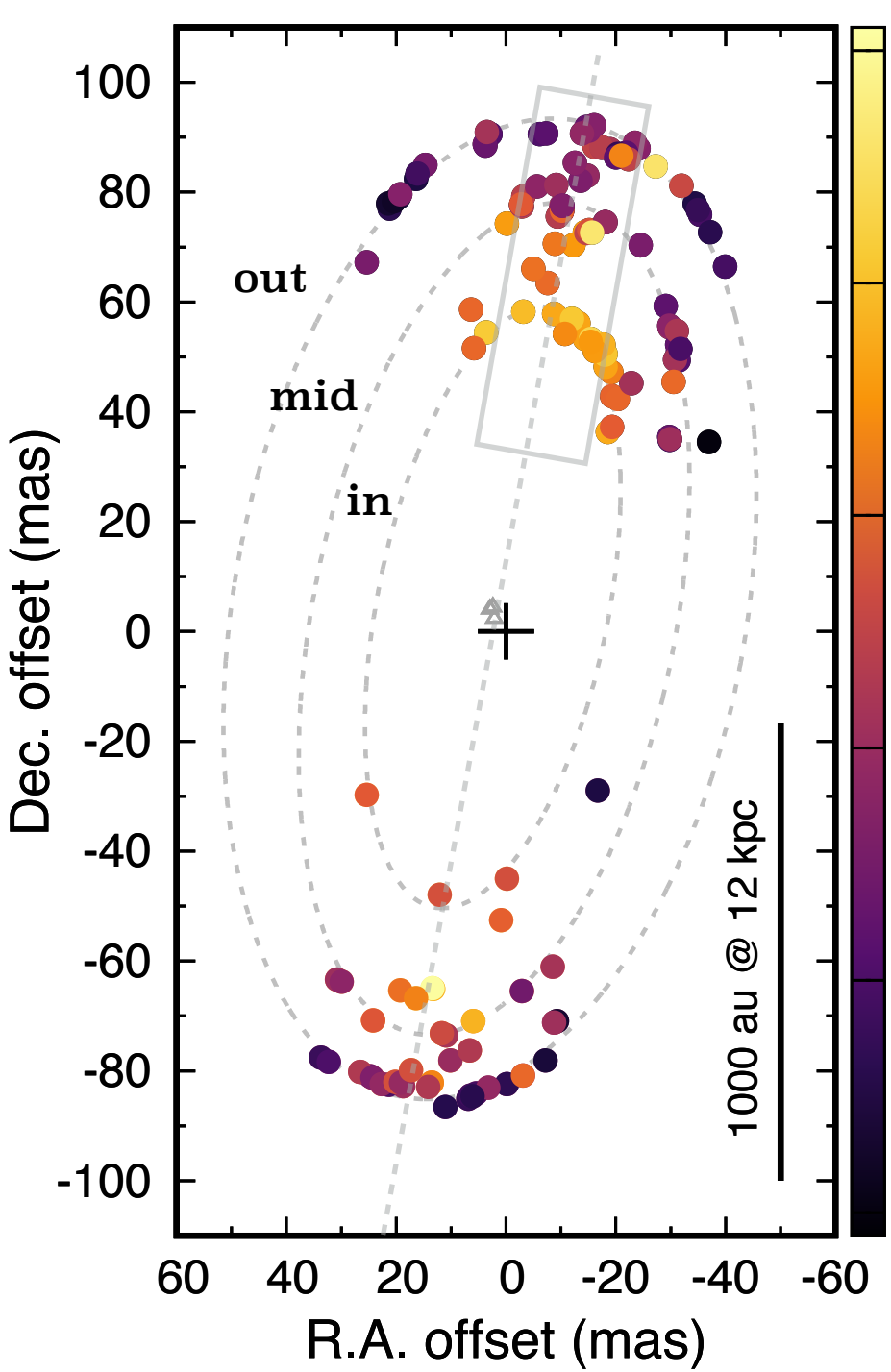
Understand the transformation from

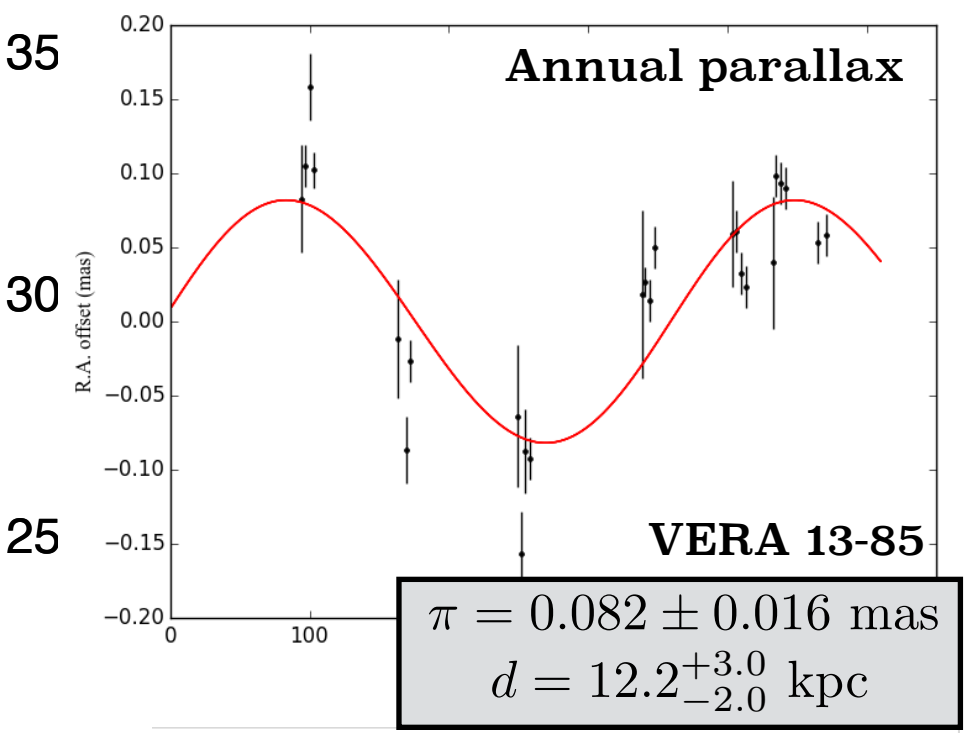
spherical mass-loss (AGB) to non-spherical (PNe)

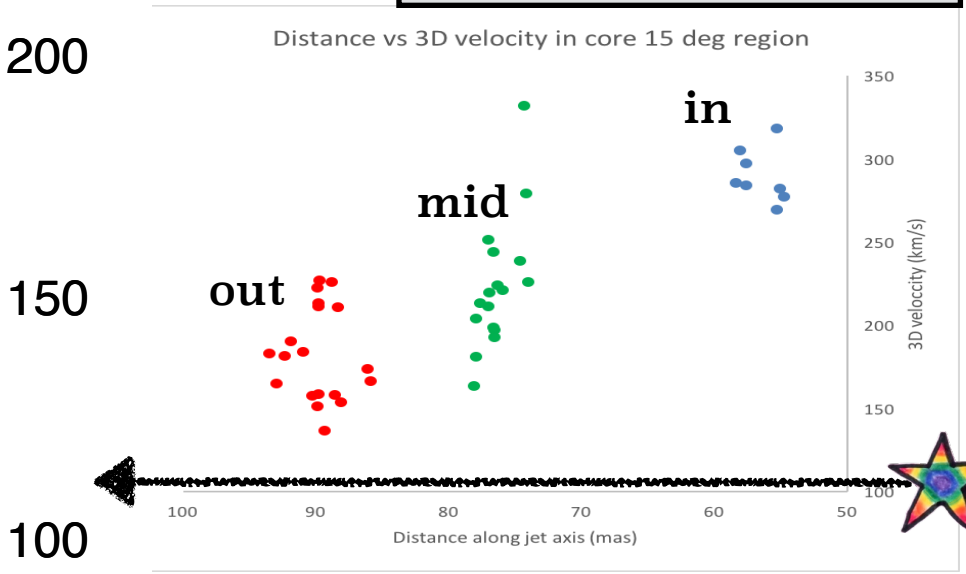
VERA
distance

VLBA
mapping jet motion

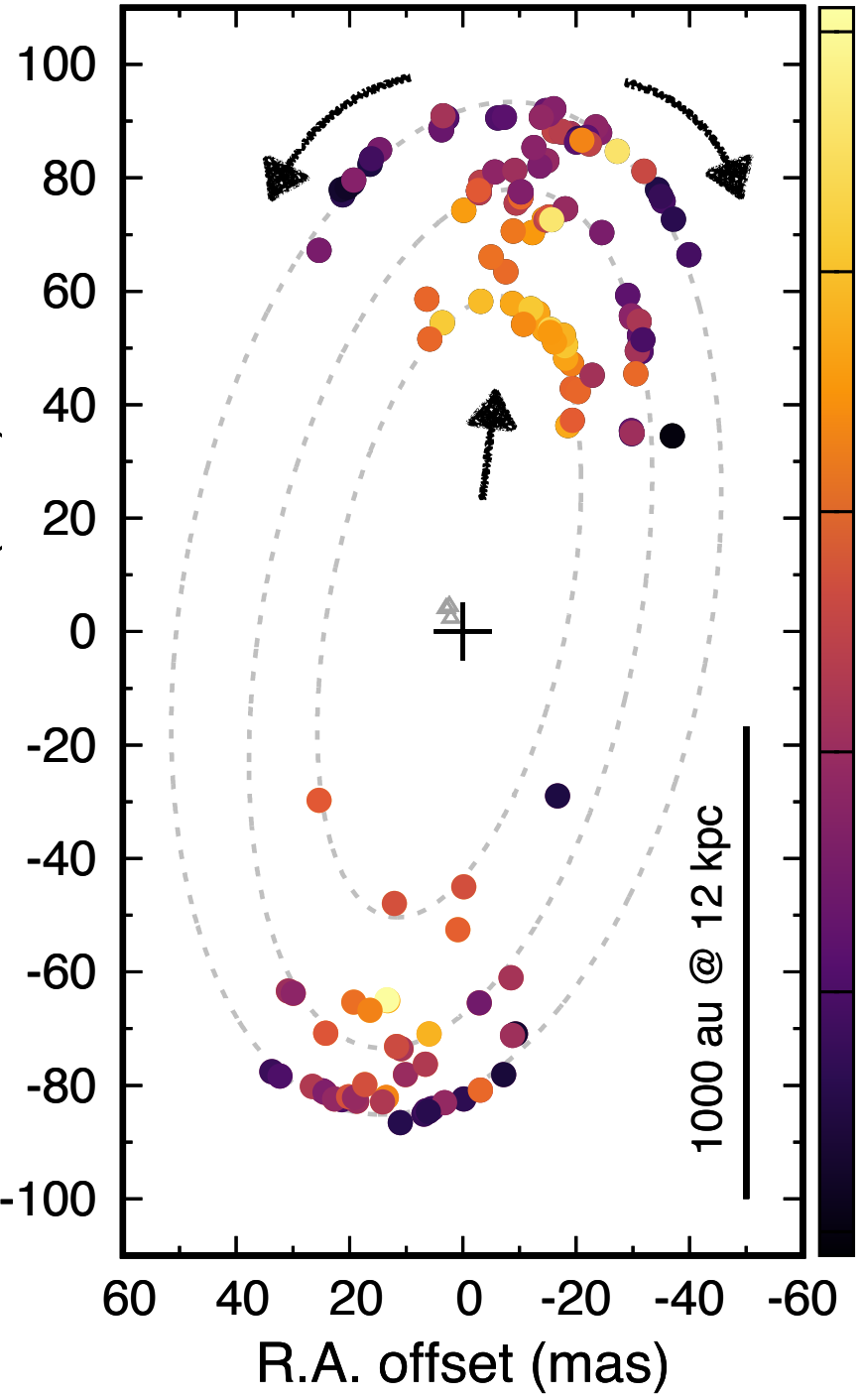

H2O masers
out
mid
in
1000 au @ 12 kpc
Dec. offset (mas)
R.A. offset (mas)
3 mas/yr
170 km/s
Wow, shocks!
I hope the next is coming soon.
VLSR (km/s)
VLBA
BG231

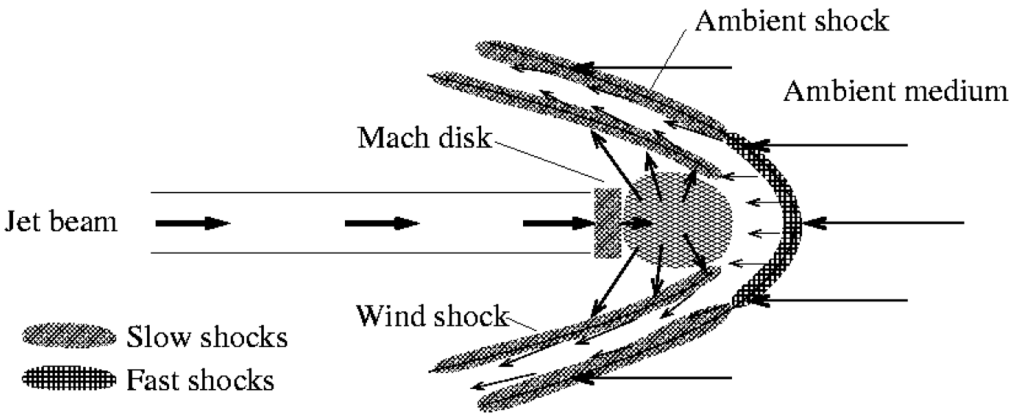






Decrease in 3D velocity

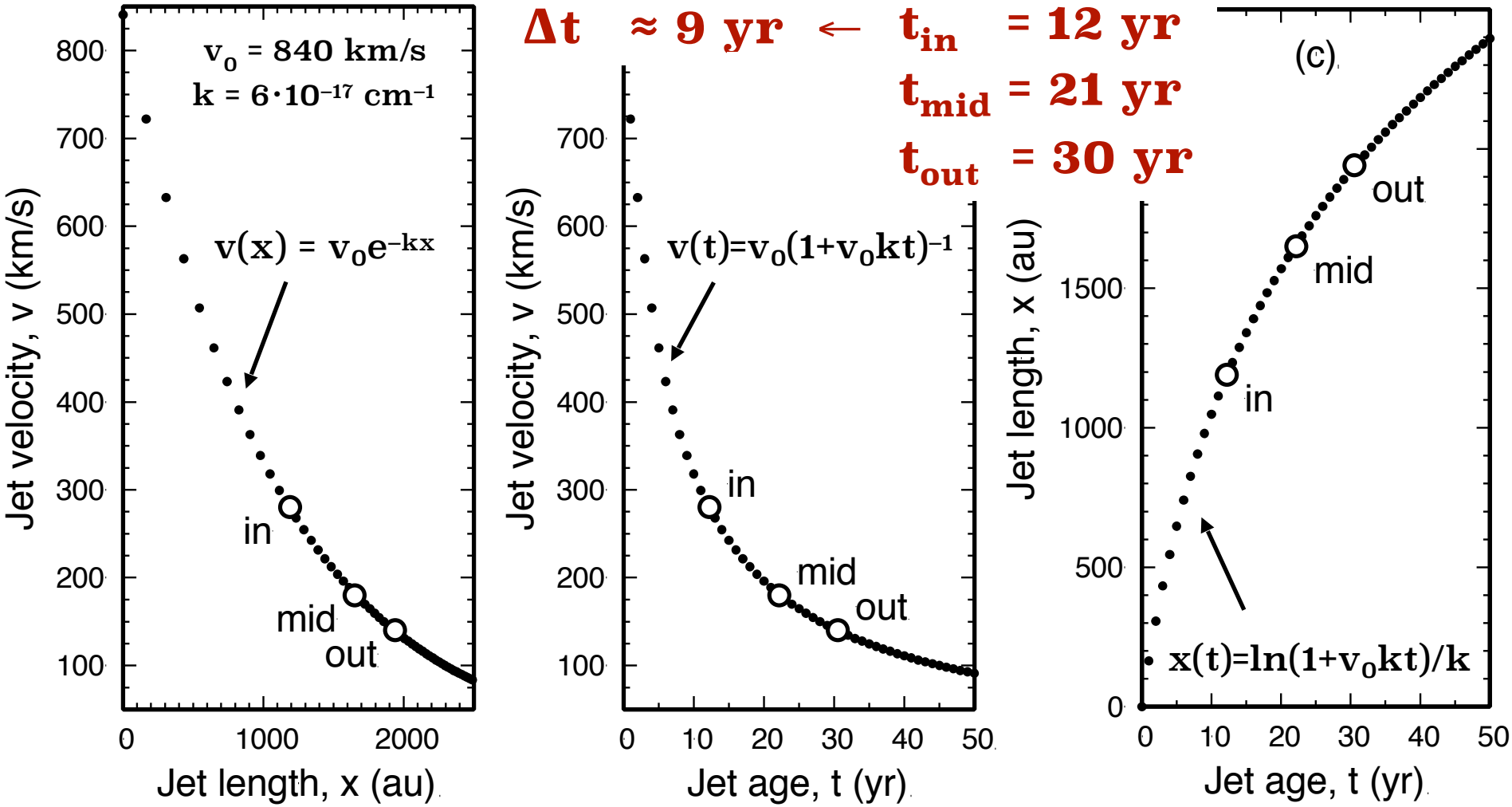




jet	size (au)	3D vel (km/s)	age *v=const* (yr)
in	1160	280	20
mid	1610	180	42
out	1890	140	64

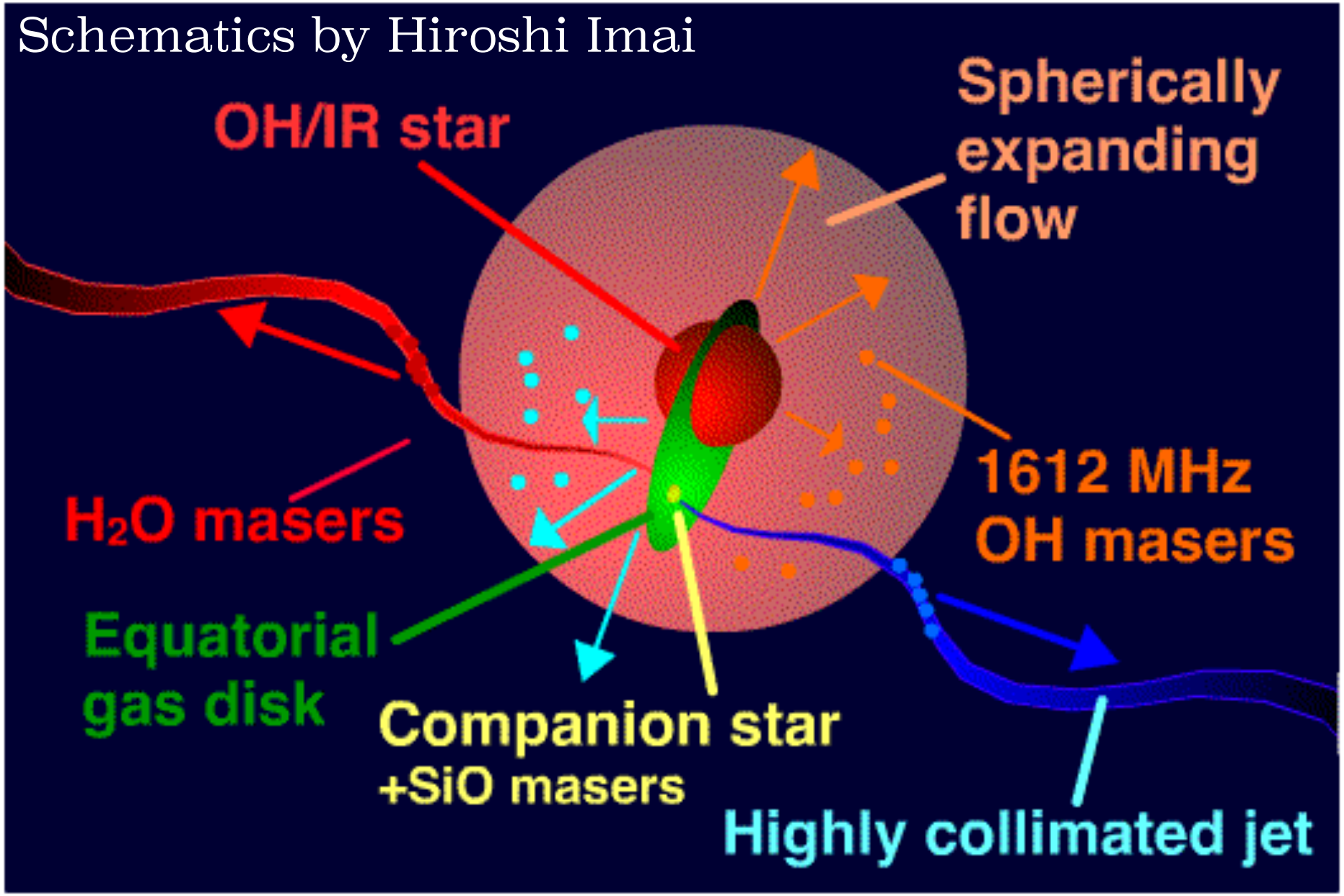
using a common inclination of i=55°

Decrease in velocity follows exponential decay



Exponential deceleration can be explained if drag forces are dominant in the motions of the maser region, $a = -kv^2$ and $v(x) = v_0 e^{-kx}$

$k = \rho C_D A/(2m)$ → **ambient density in CSE: $\rho \approx 10^6$ cm^{-3}**



Most theoretical models agree: we need binaries for collimated outflows in evolved systems

Proposed general scenario of a binary system

Rapidly-evolving episodic jet ejections due to a binary system, with an accretion disk formed around one of the components of the binary (to collimate the outflow).

Orbital motions of the binary in an elliptical orbit could produce a periodicity in the ejection.

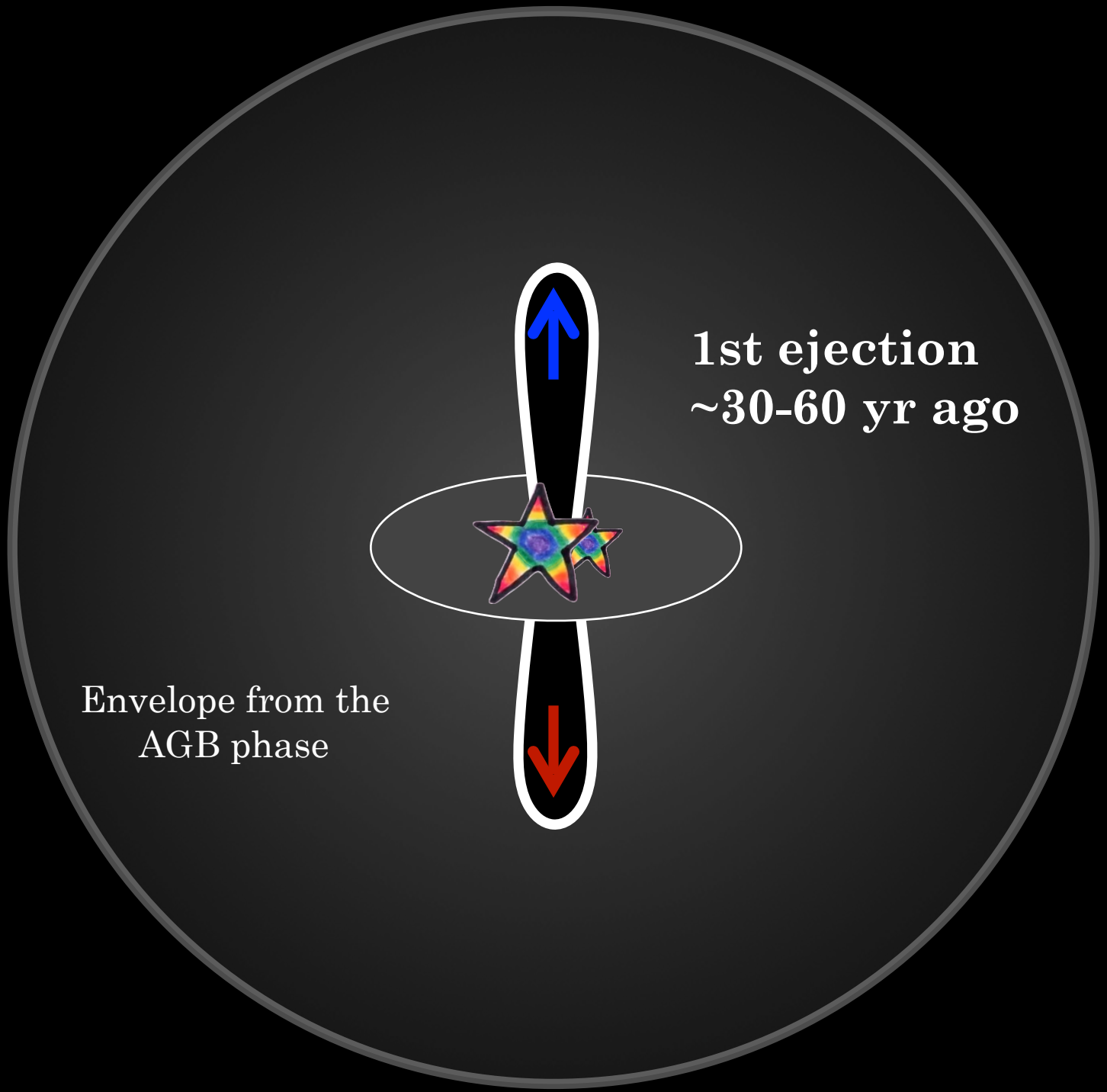
Assuming $M_{\star}$ (total) = 2 $M_{\odot}$, period ~10–20 yr

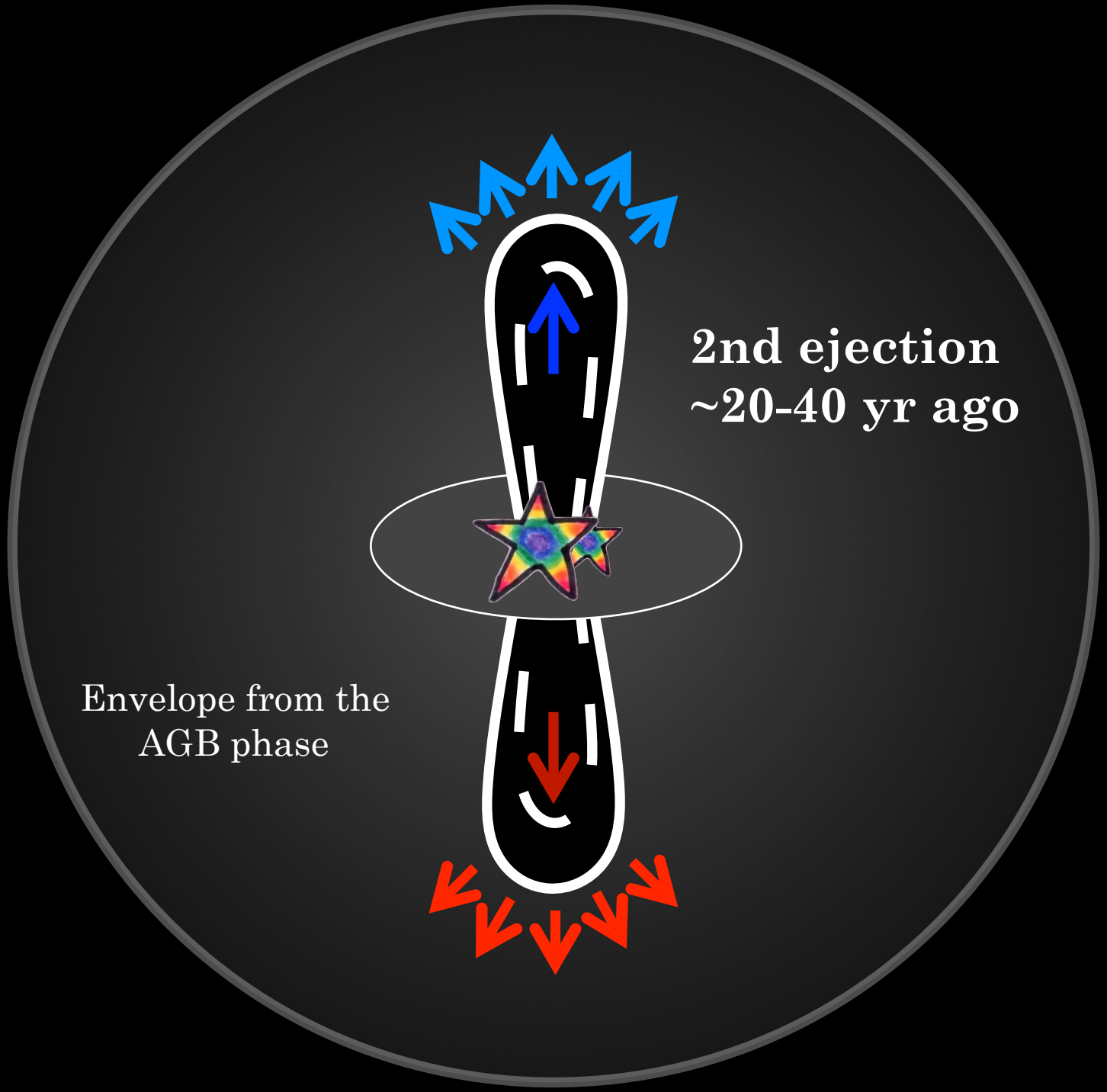
➔ Binary separation ~10 au (~1 mas)

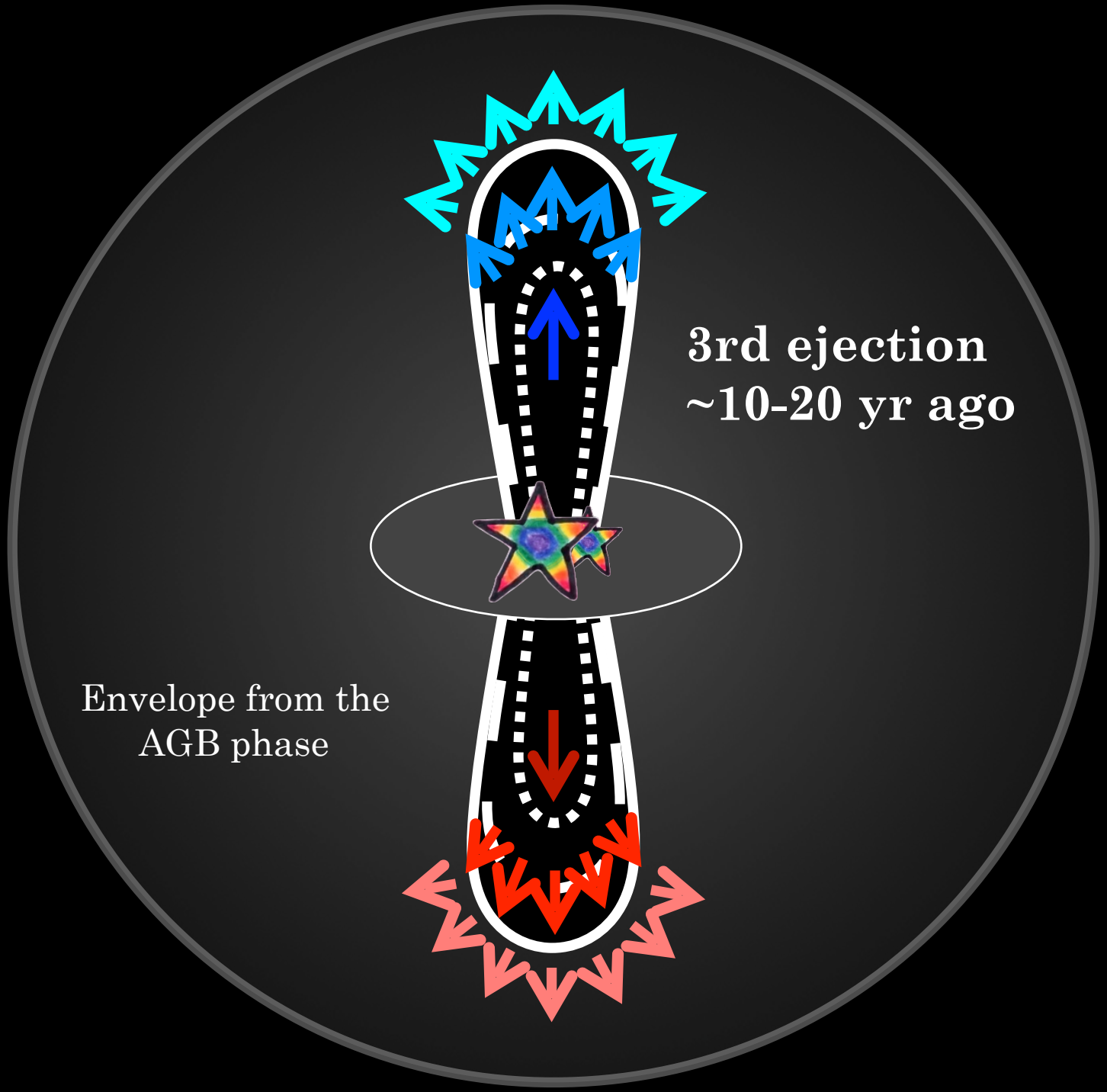
The type of the binary is impossible confine with present data.

An orbital period of 10 yrs and the high density in the polar direction might point to wind Roche-lobe overflow and a low-mass companion.

We need observations of thermal molecular lines to say more…

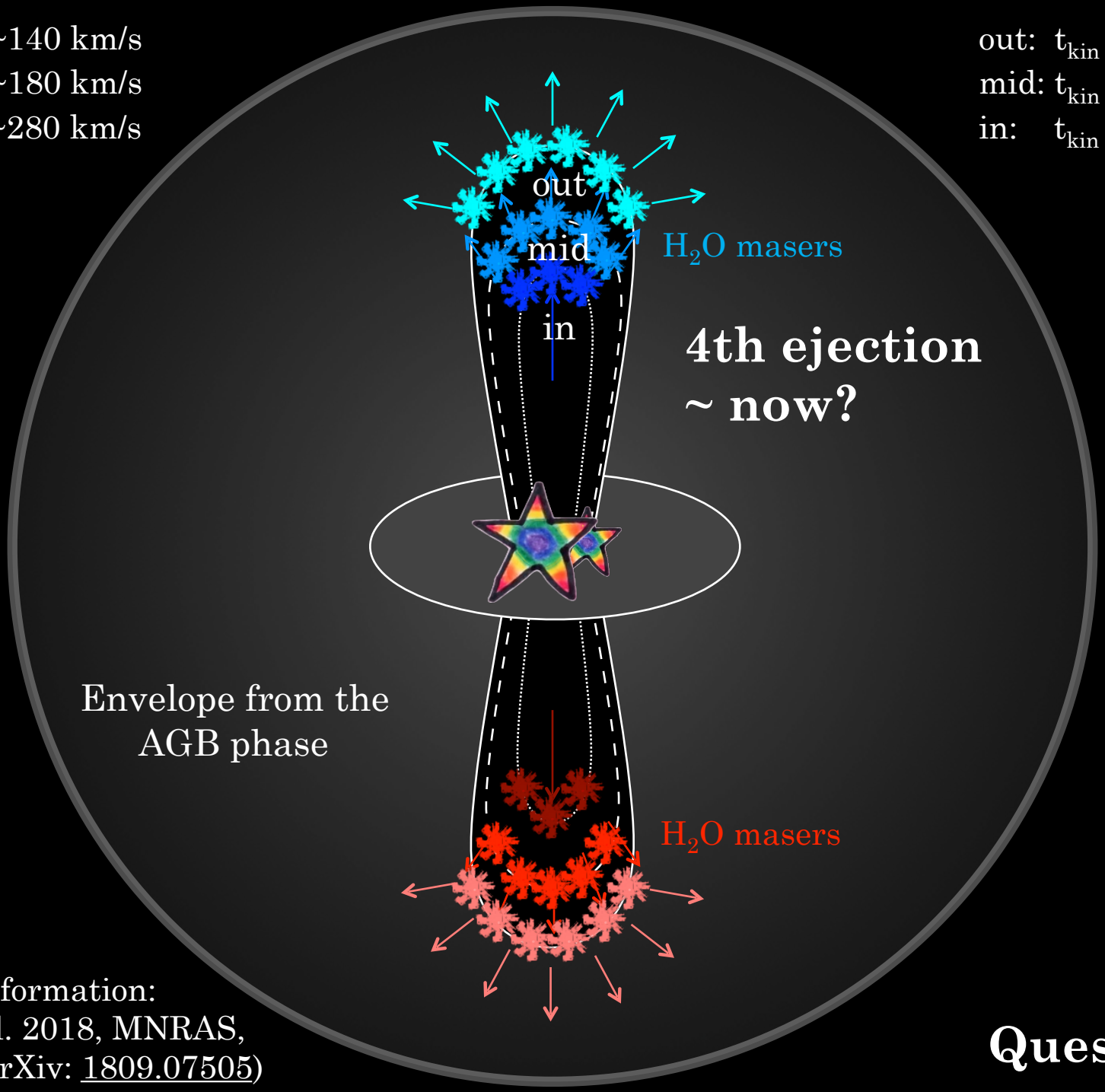

1st ejection
~30-60 yr ago
Envelope from the
AGB phase


2nd ejection
~20-40 yr ago
Envelope from the
AGB phase


3rd ejection
~10-20 yr ago
Envelope from the
AGB phase

out: V_{exp} ~140 km/s
mid: V_{exp} ~180 km/s
in: V_{exp} ~280 km/s

out: t_{kin} ~30-60 yr
mid: t_{kin} ~20-40 yr
in: t_{kin} ~10-20 yr



Further information:
Orosz et al. 2018, MNRAS,
in press (arXiv: 1809.07505)

fin.
Questions?