

RRLs as a tool to study ionized outflows and disks around massive stars

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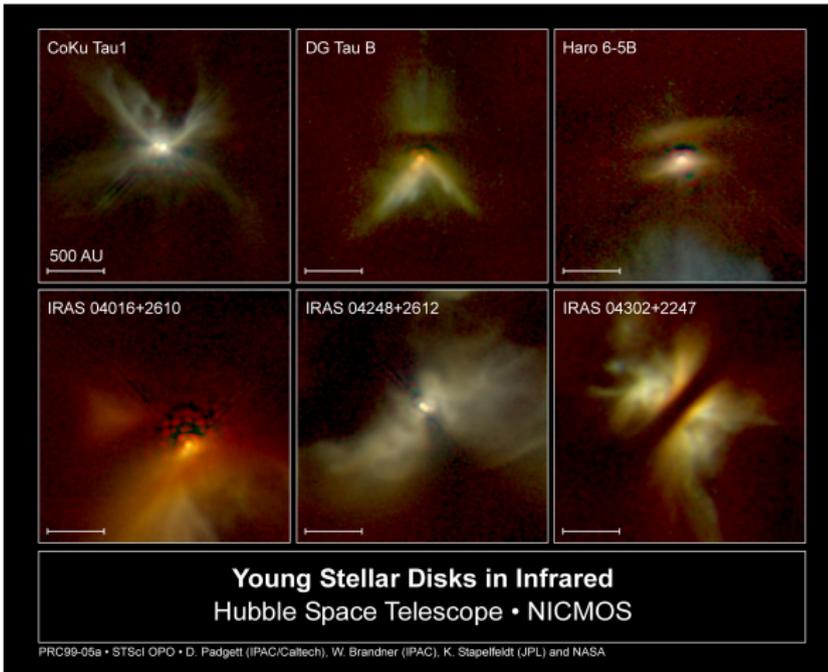
Supervisor: Jesús Martín-Pintado

Star and Planet Formation Workshop.
ESAC. Villanueva de la Canada

21 January 2013

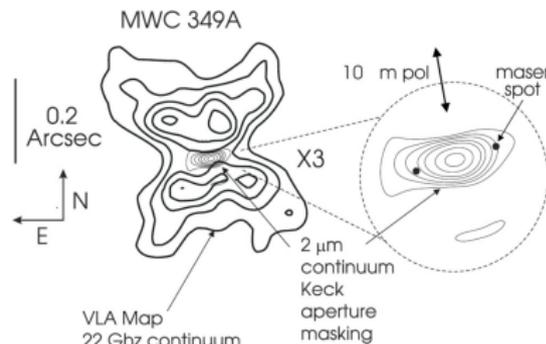
Motivation

- Low-mass star formation: \Rightarrow accretion of material through circumstellar disks



Motivation

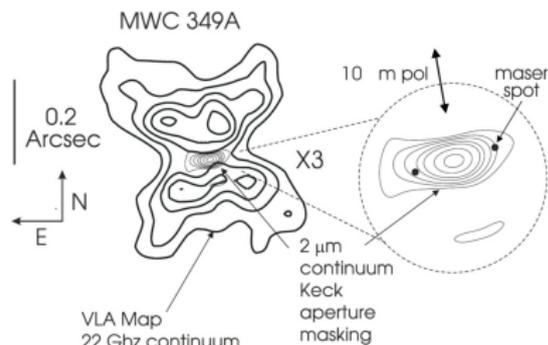
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- High-mass star formation: \Rightarrow ?
 - Evidence of circumstellar disks around massive stars



Danchi et al. 2001, ApJ, 562, 440

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Danchi et al. 2001, ApJ, 562, 440

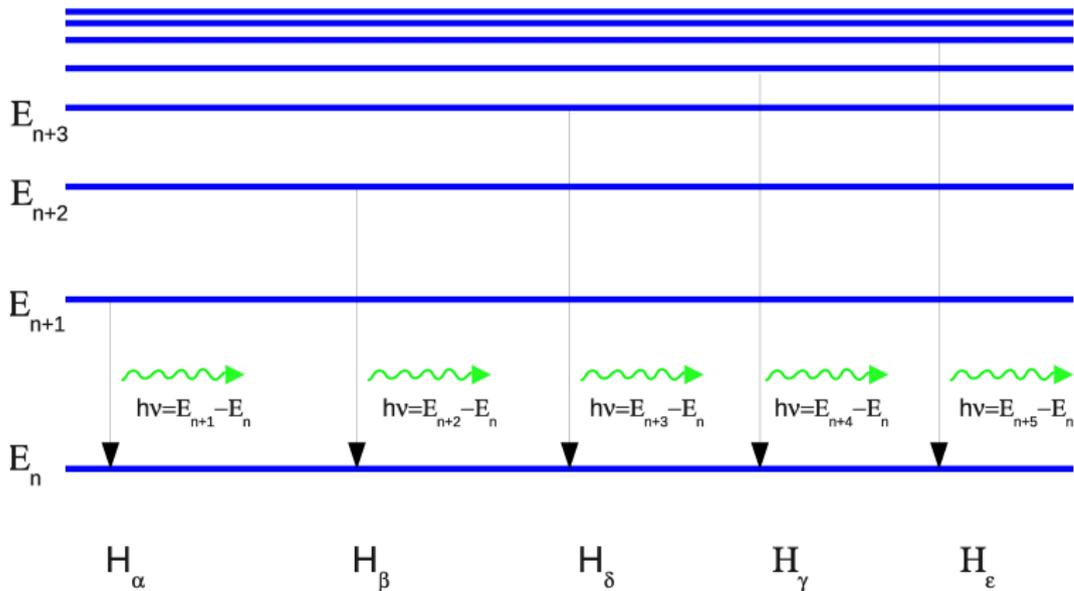
Motivation

Understanding the kinematics of circumstellar disks and their associated outflows



Motivation

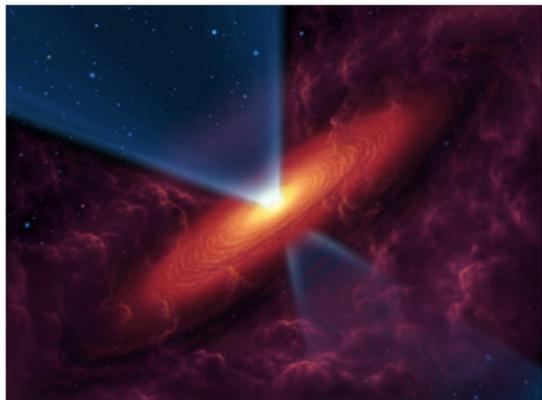
- Radio-recombination lines





Motivation

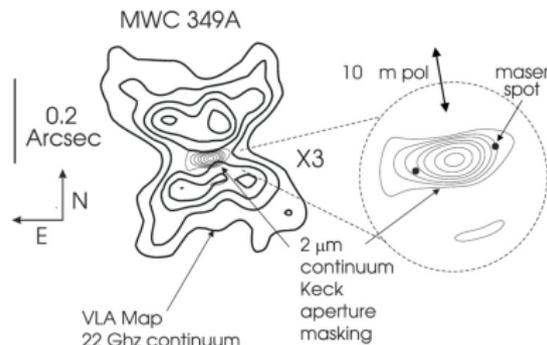
- Radio-recombination lines
- Stellar winds.
UC-HII regions: $\Delta v > 10$ km/s





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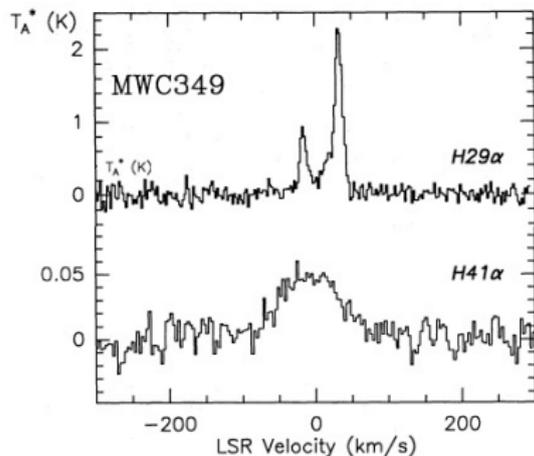
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- MWC349A
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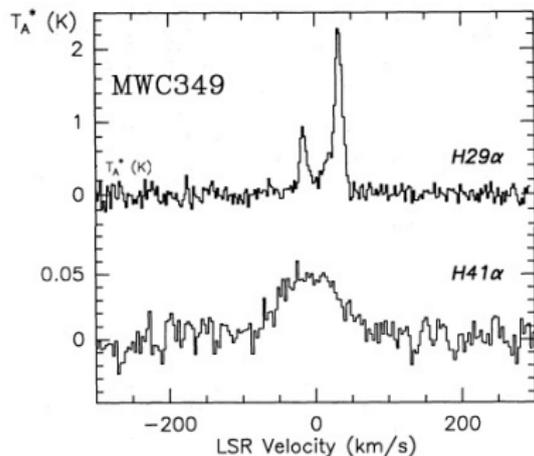
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 - Maser and laser emission at Hydrogen recombination lines
 - Their high intensity makes possible to have a high spectral and angular resolution



Martín-Pintado et al. 1989, A&A, 215, L13

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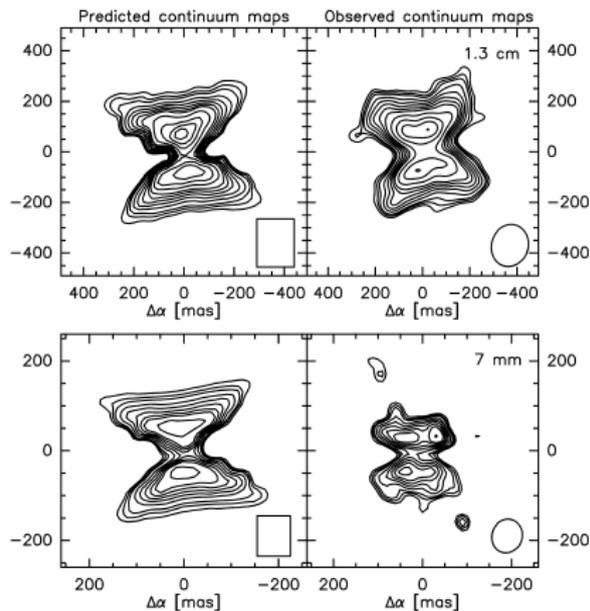
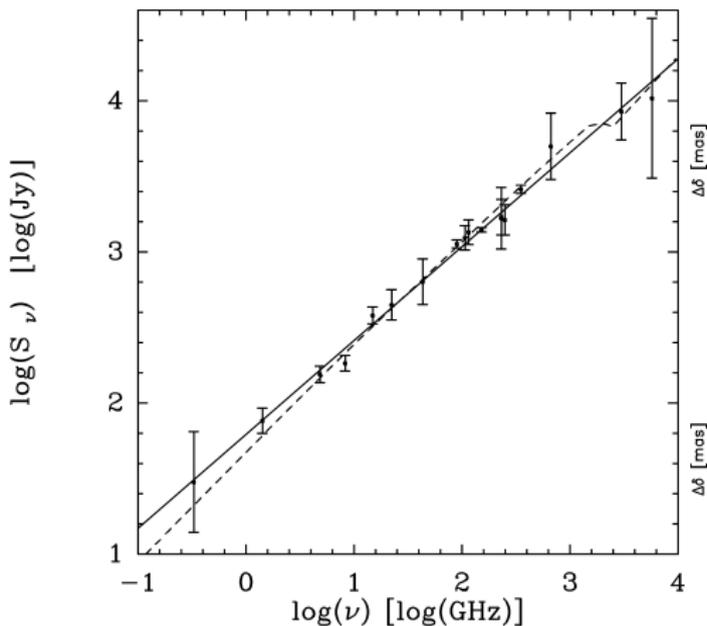
Martín-Pintado et al. 1989, A&A, 215, L13

3D non-LTE radiative-transfer model

MORELI (*MOdel for REcombination Lines*)

Báez-Rubio, A., Martín-Pintado, J., Thum, C. & Planesas, P.
2013, A&A submitted

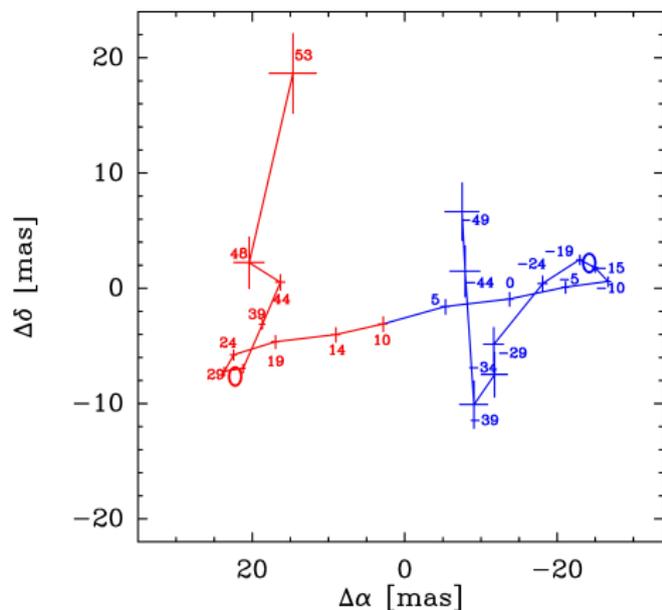
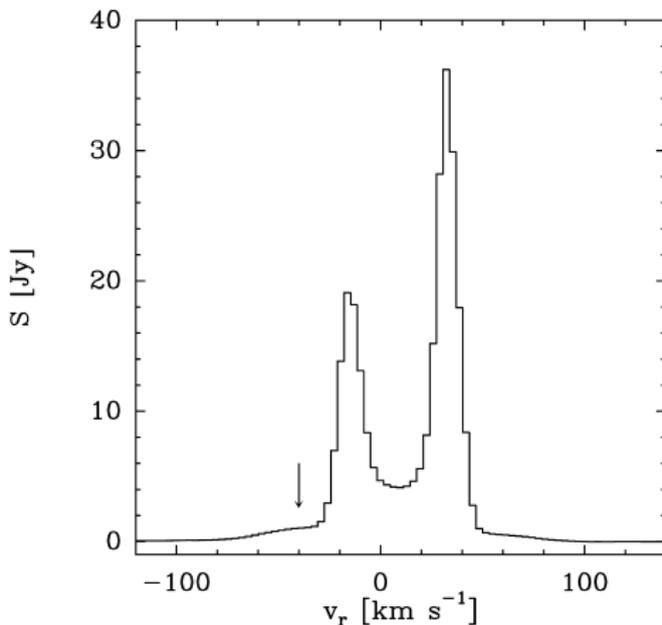
Physical parameters derived from radio-continuum emission



$$N_e(r=6.7 \text{ AU}, \theta=\theta_a)=3.85 \cdot 10^9 \text{ cm}^{-3} \quad \theta_a=57^\circ \quad T_{wind}=12000 \text{ K}$$

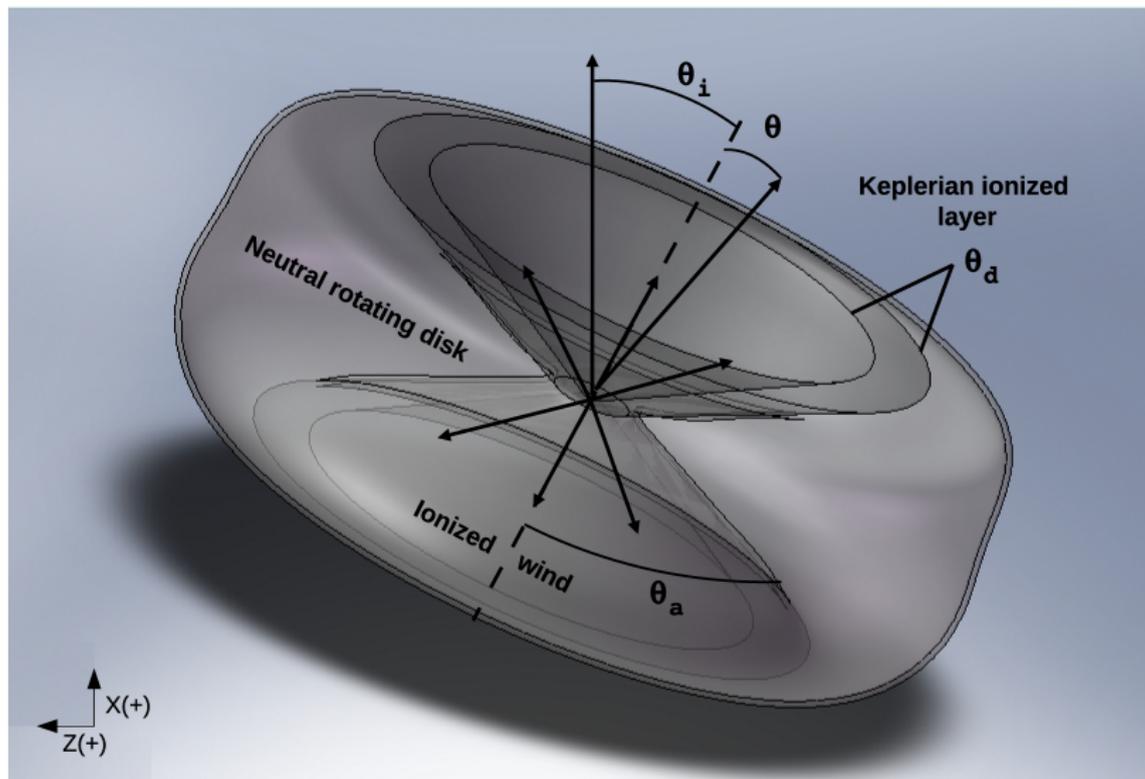
$$N_e(r, \theta)=N_e(r=1, \theta=\theta_a) \frac{e^{(\theta_a-\theta)/20}}{r^{2.14}}$$

H30 α (231.9 GHz) radio-recombination line

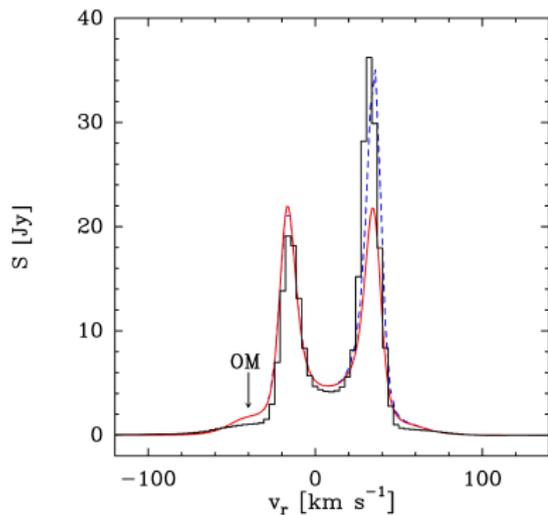
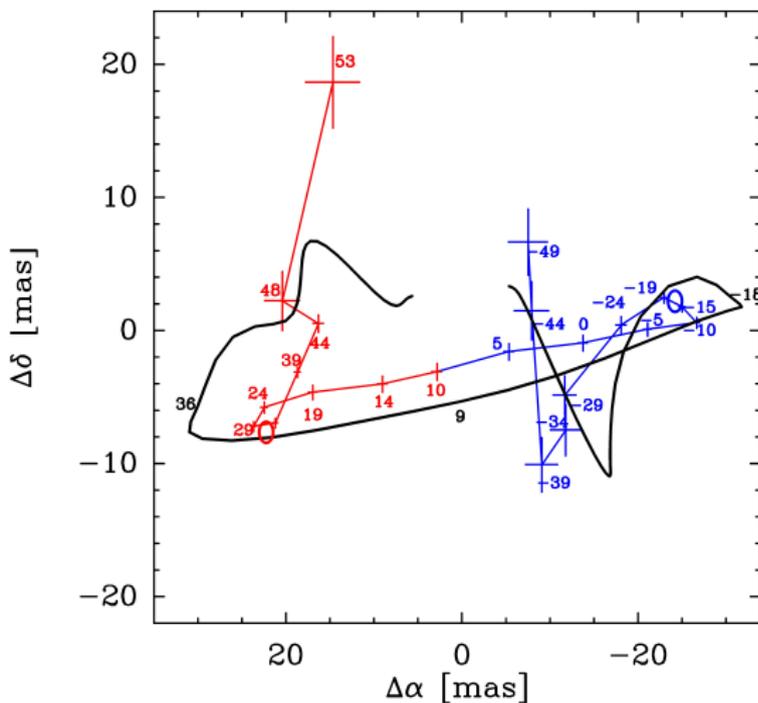


Martín-Pintado et al. 2011, A&A, 530, L15

Kinematic model

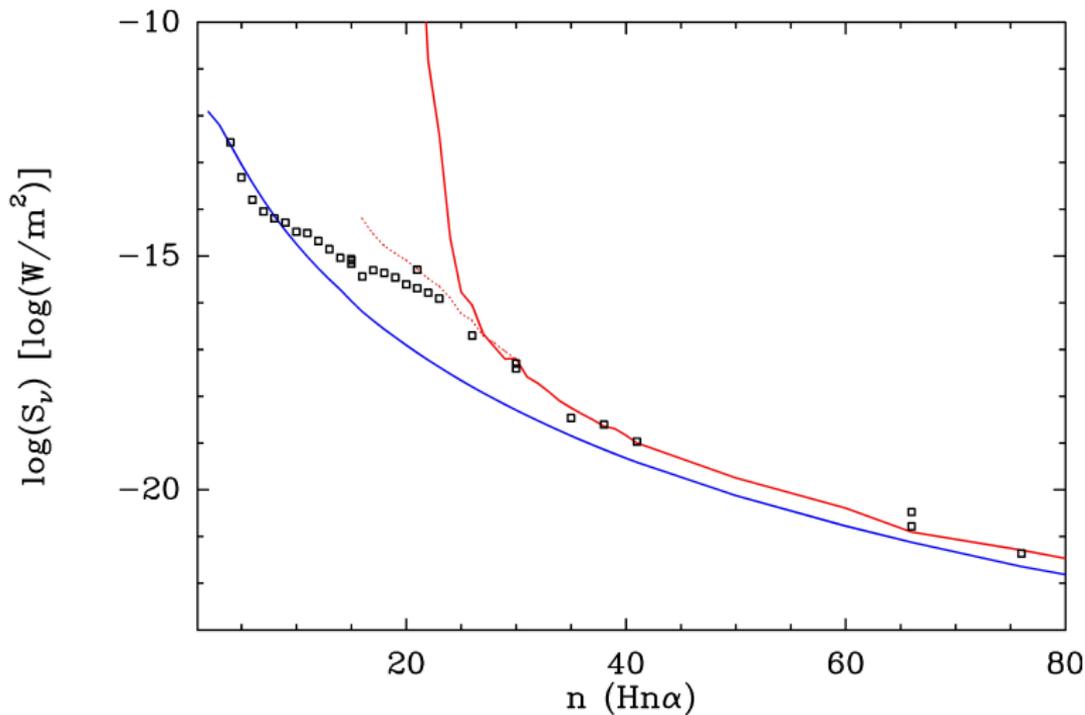


Constraining the kinematics

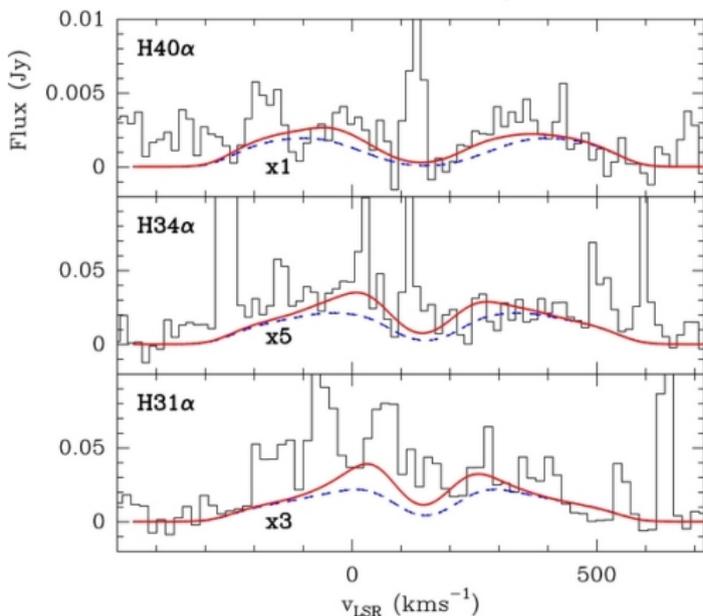


M	$40M_{\text{sun}}$
θ_i	8°
θ_k	6.5°
r_{min}	0.05 AU
v_{exp}	60 km/s

Integrated-line fluxes

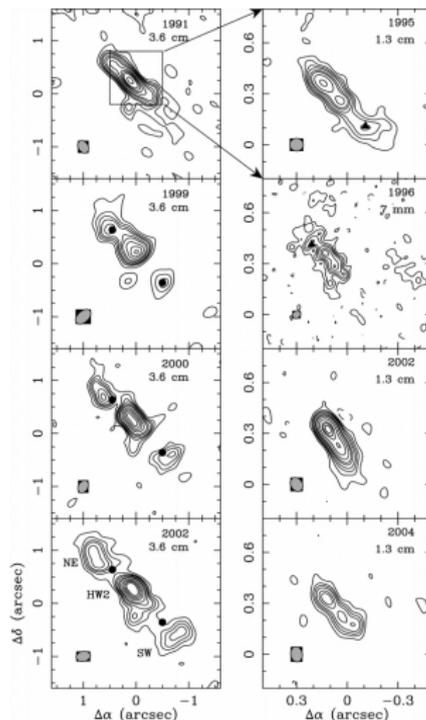


Other RRL maser sources: Cep A HW2



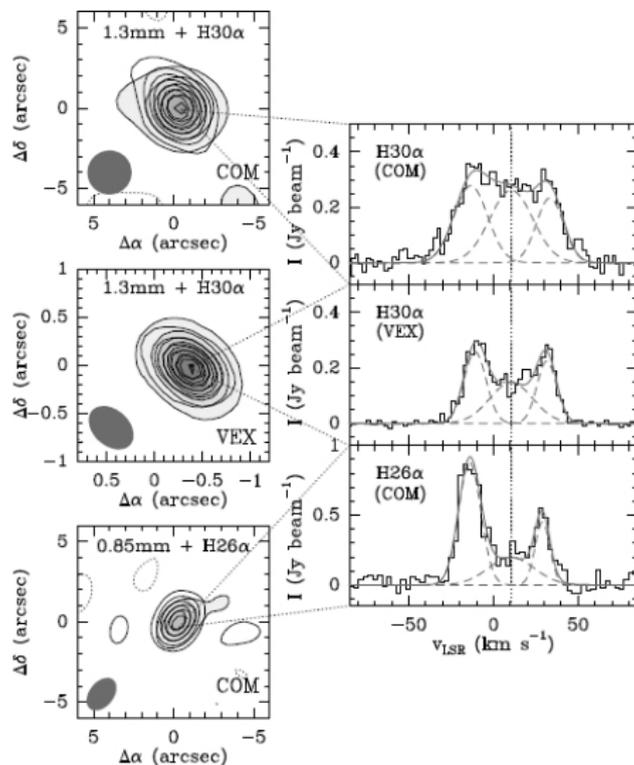
Jiménez-Serra, I., Martín-Pintado, J., Báez-Rubio, A. et al.

2011, ApJ, 732, L27



Curiel, S., Ho, P., Patel, N. et al. 2006, ApJ, 638, 878

Other RRL maser sources: MonR2-IRS2



Conclusions

MWC349A

- Radio-recombination lines are an excellent tool to study the kinematics of UC-HII regions.
- Stellar ionized wind is rotating
- Stellar ionized wind acceleration happens in short distances and from very inner radii

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General

- A new field in the study of massive star formation is emerging with the new instrument capabilities

Thank you for your attention! :-)

Gracias!

