Kinematics of warm* water

Warm water in a deeply embedded low-mass protostar

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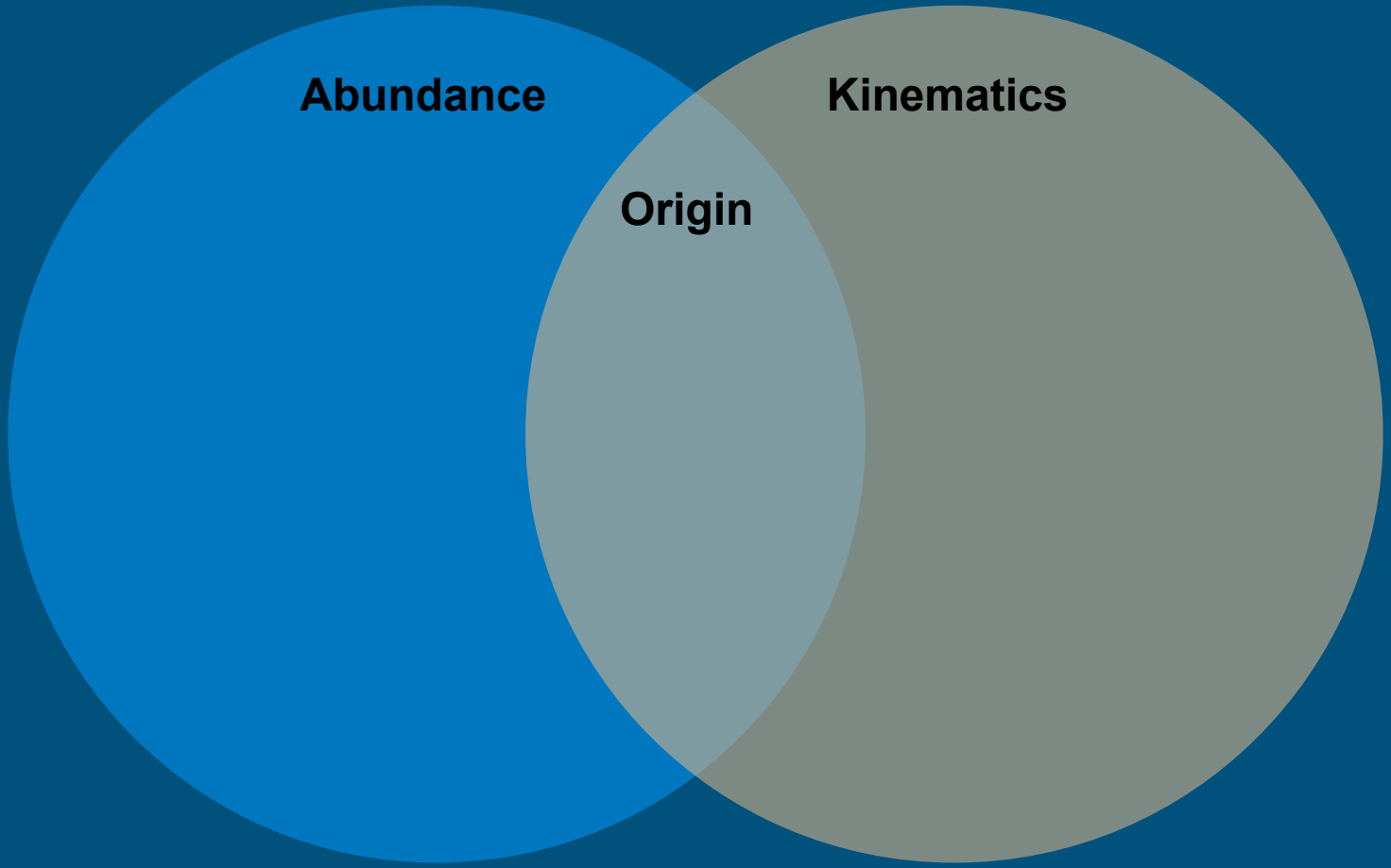
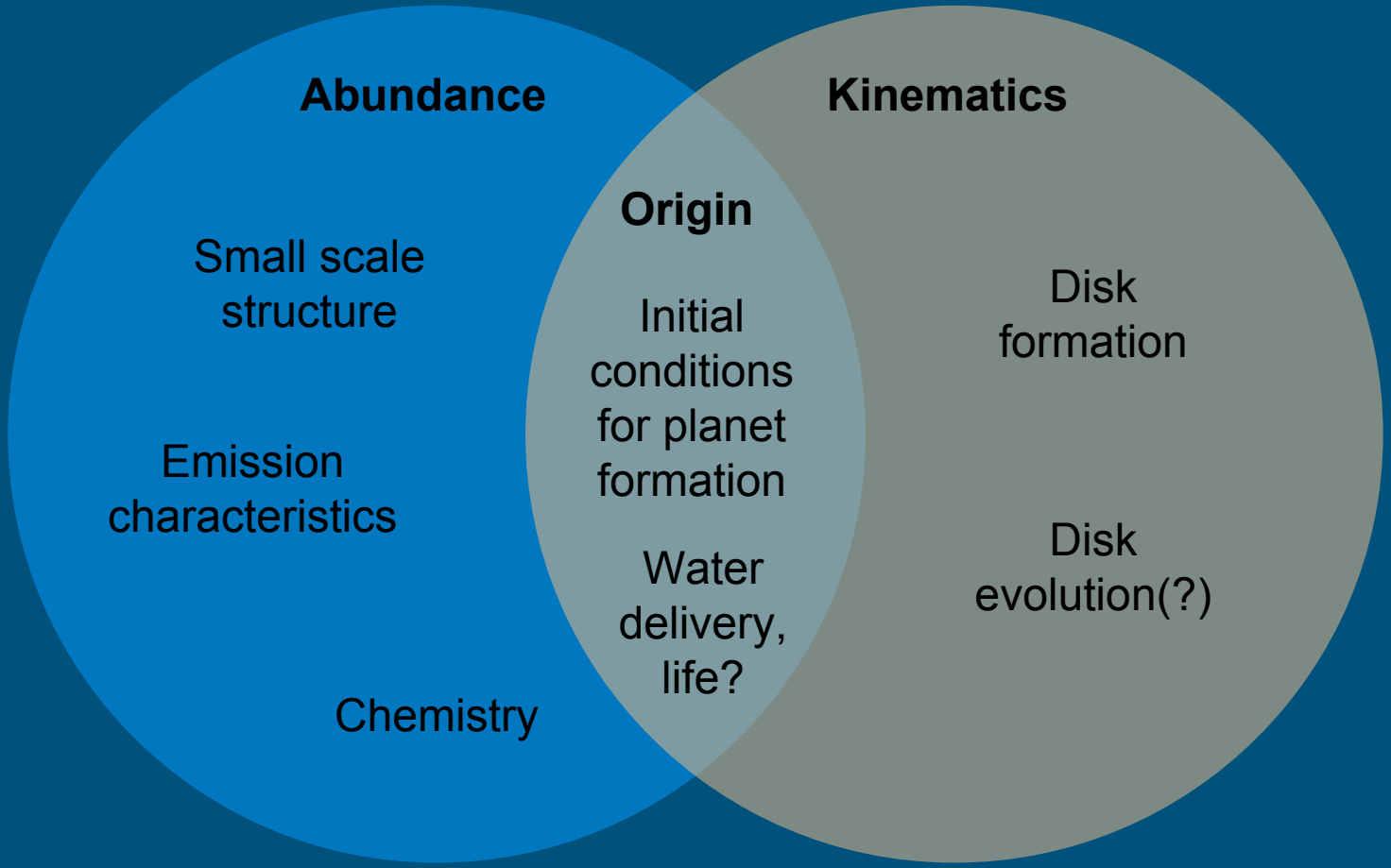
* 100~200 K

Warm water - What we want to determine



Warm water - What we want to determine

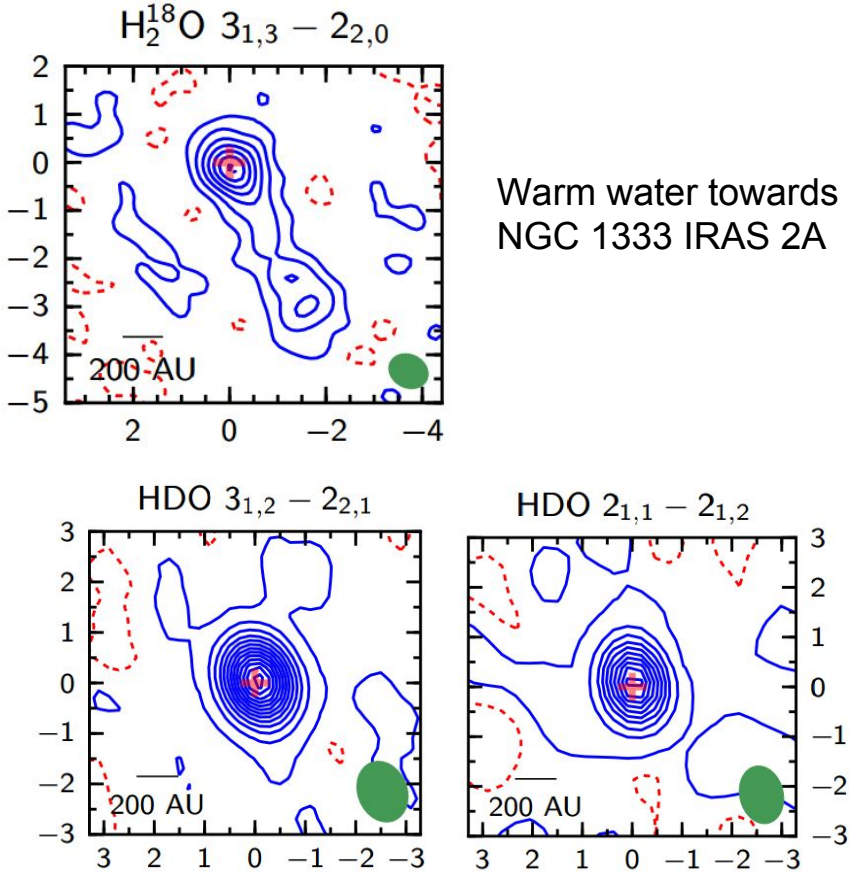


Warm water - Detectability

(Warm) Water observable from the ground.

Class 0 protostars

T_{ex} = 100~200 K



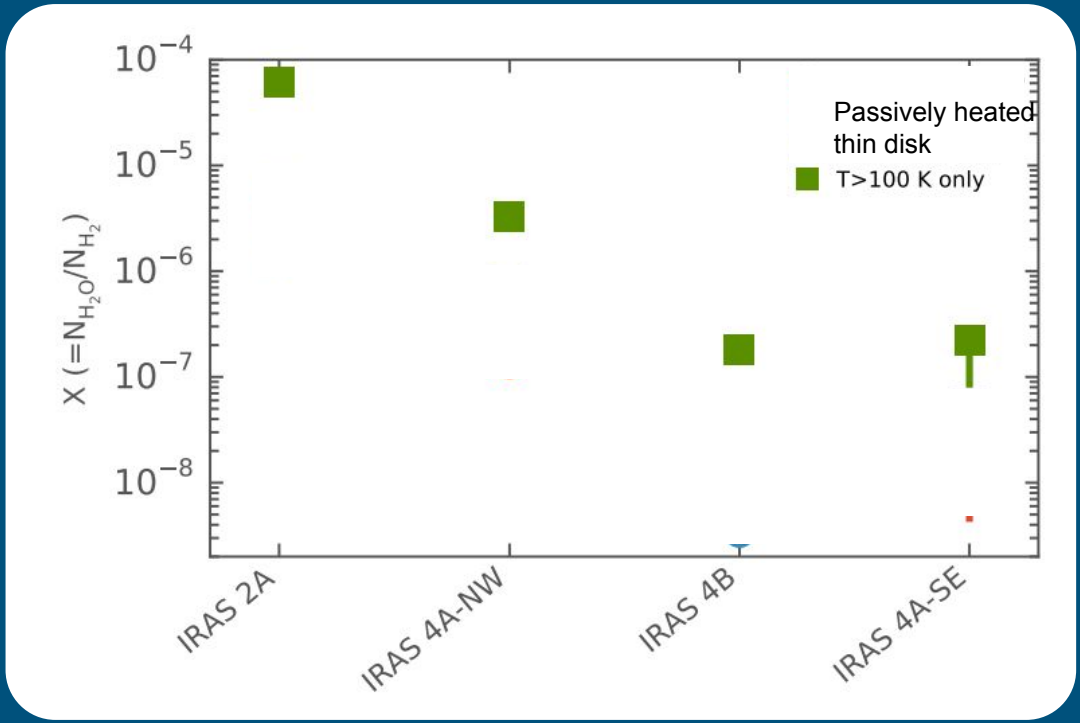
Warm water towards NGC 1333 IRAS 2A

Persson+14

Jacq+88, Gensheimer+96, van der Tak+06, Codella+10, Jørgensen & van Dishoeck+10, Persson+12,13,14, Coutens+14,15, ...

Warm water - Abundance

Accounting for structure the water abundance increases*. Hot corinos still not ‘wet’, c.f 1x10^{-4}



Persson+16

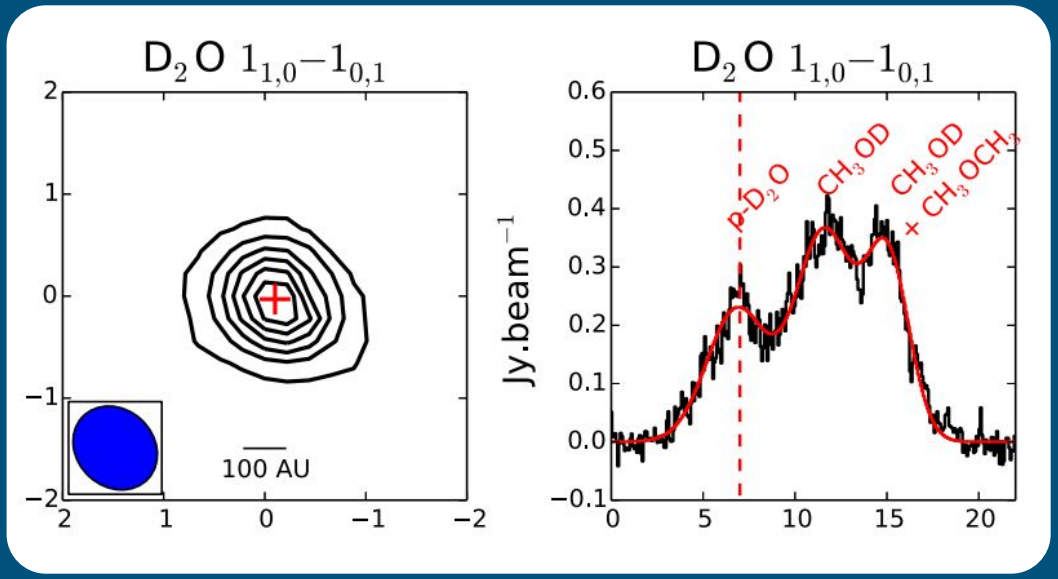
*no vertical structure, i.e. could increase more

Warm water - Chemistry

With the various deuterated forms of water we can derive the D/H ratio.

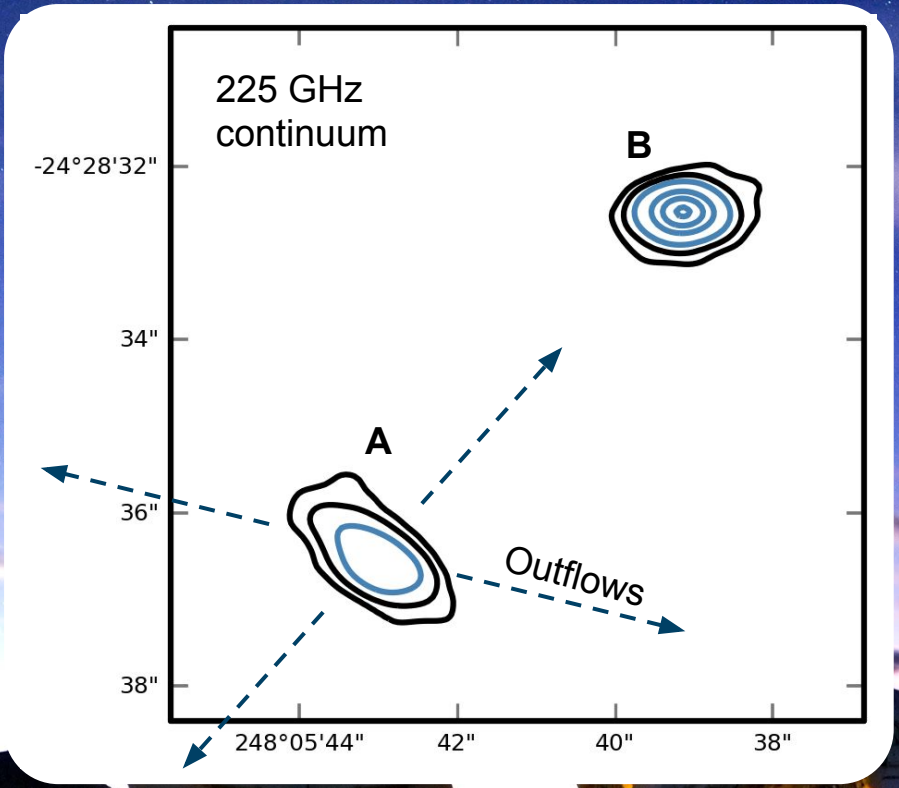
Talk on this by **Audrey Coutens** in **~10 minutes.**

Warm D_2O towards IRAS 2A



Coutens+15

Warm water - IRAS 16293-2422 (binary)



PI: A. Coutens

ALMA Cycle 3

IRAS 16293-2422

ρ Ophiuchus, 120 pc

1 $H_2{}^{18}O$, 6 HDO, 1 D_2O

~0.3" resolution

IRAS 16293-2422 A - Kinematics (Previous)

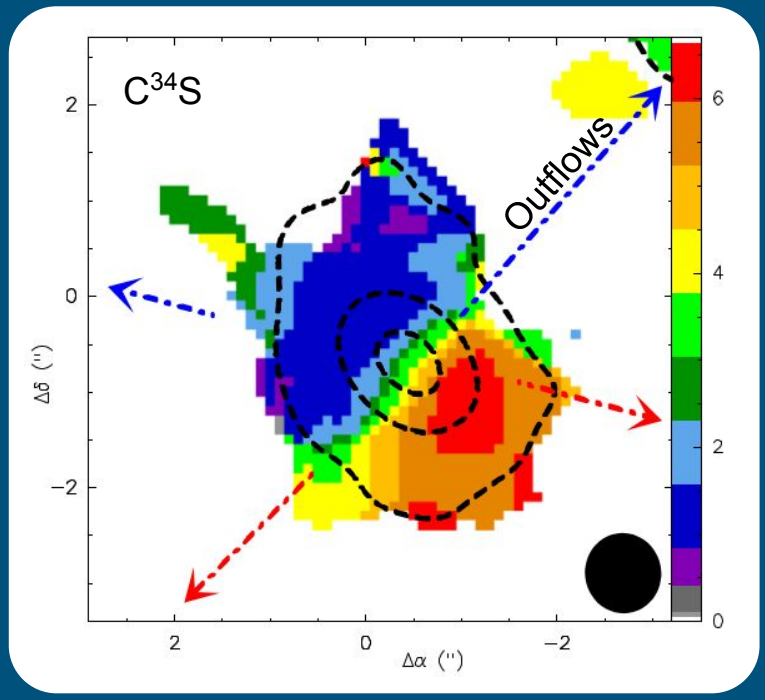
Interesting kinematics, **previous observations of $C^{34}S$ have given different results**

Girart+13: Best fit Keplerian disk, M_*=2.3 M_{sun}.

Fauvre+15: Best fit Keplerian disk, M_*=0.49 M_{sun}.

Non-Keplerian rotating structures (infall with conservation of angular momentum) could be responsible for the kinematics (r_c=52 AU).

Velocity map (SMA)



Girart+13

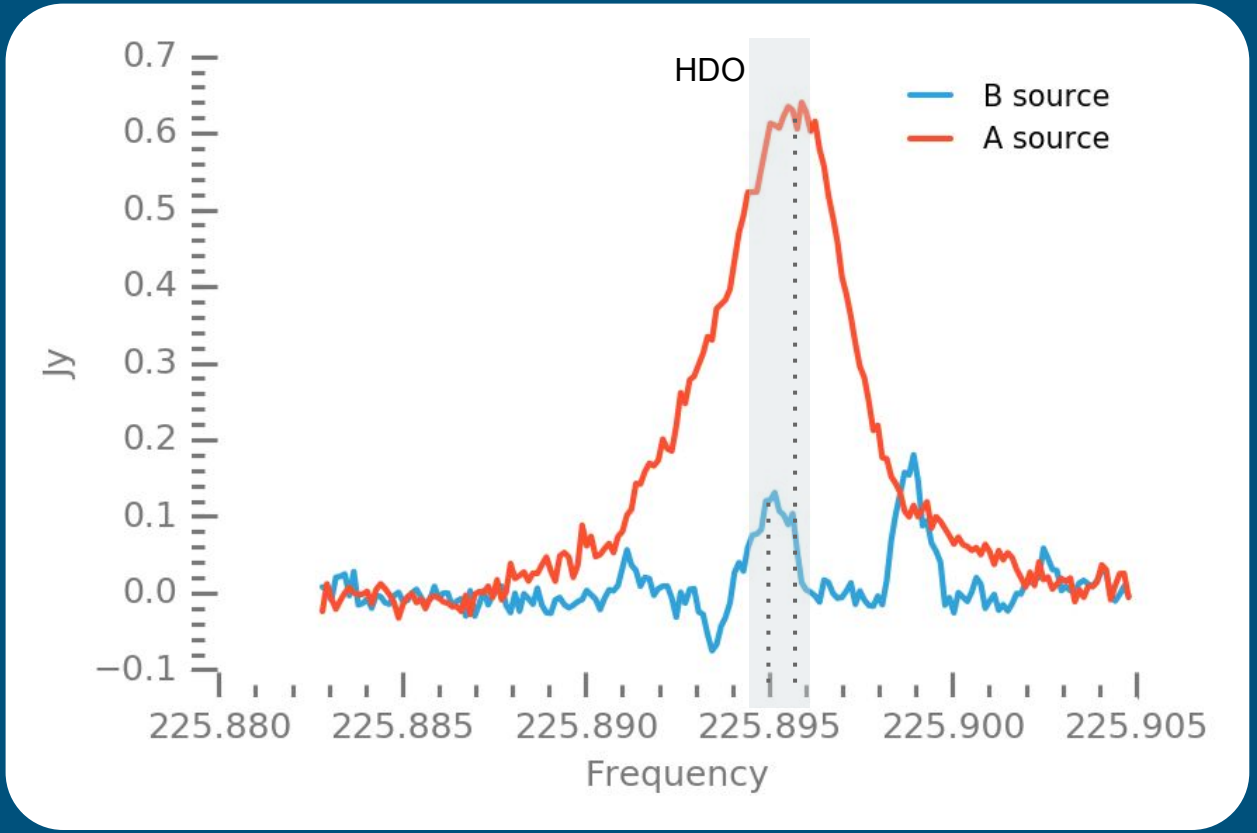
IRAS 16293-2422 - HDO $3_{1,2}$–$2_{2,1}$

Spectrum toward both sources of the binary.

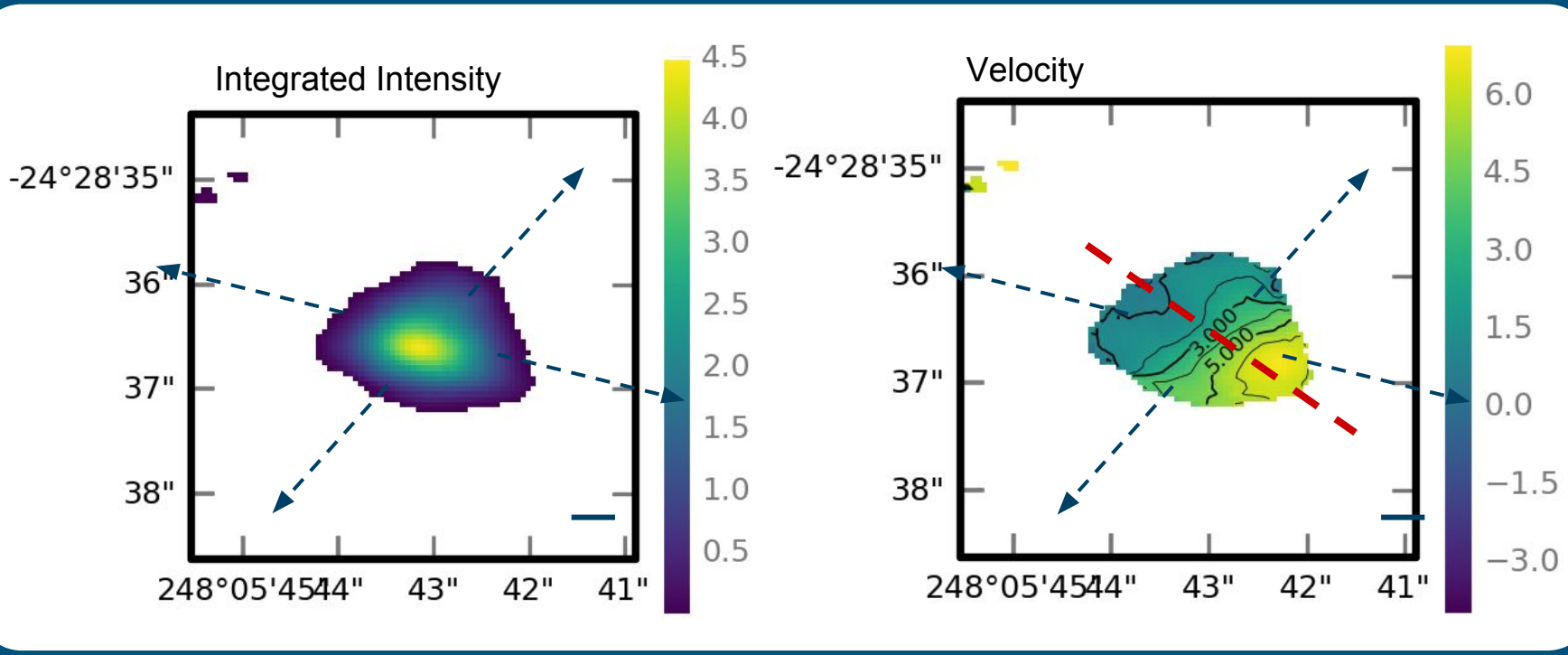
E_{up} = 167.6 K

v = 225.89 GHz

Clear detection toward both sources

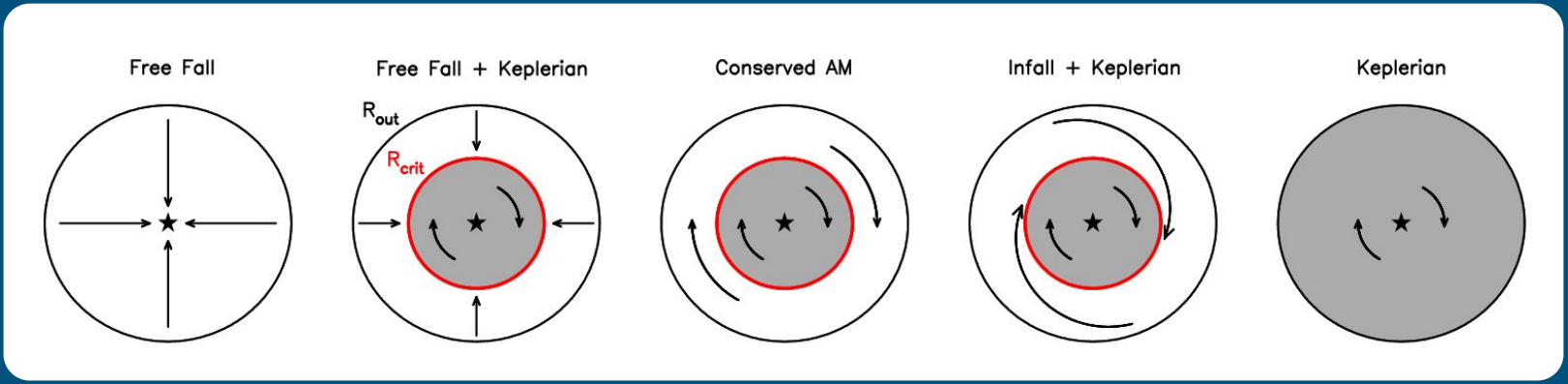


IRAS 16293-2422 A - HDO



IRAS 16293-2422 A - Kinematics of water

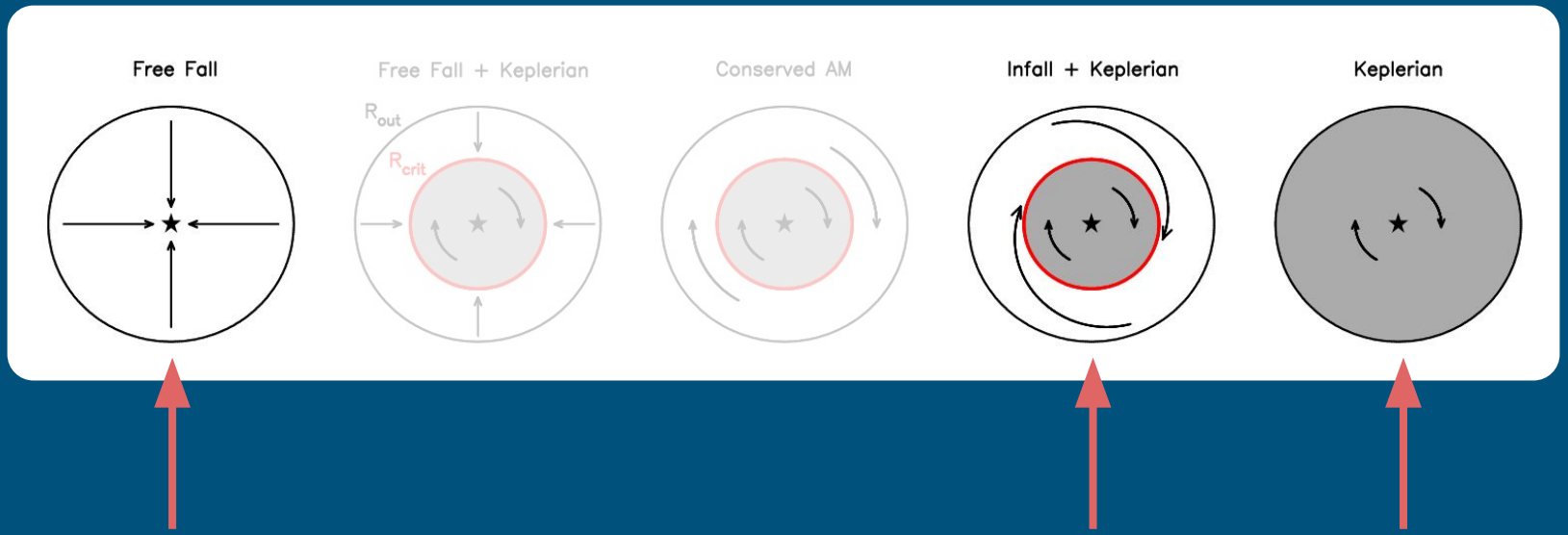
We are currently testing various kinematical configurations to model the emission.
Similar to the analysis of VLA 1623 by Nadia Murillo. First we have made our initial analysis with Position-Velocity diagrams.



Murillo+15

IRAS 16293-2422 A - Kinematics of water

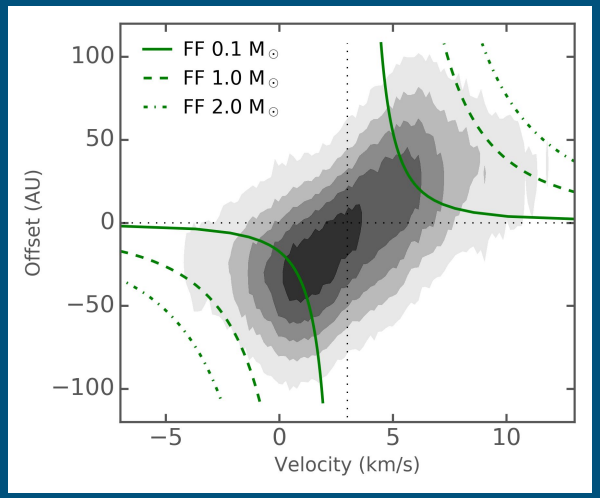
Starting out by focusing on these three cases.



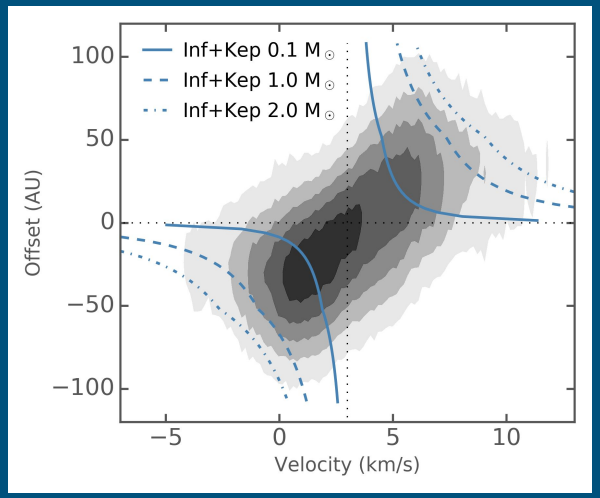
Murillo+15

IRAS 16293-2422 A - Kinematics of water

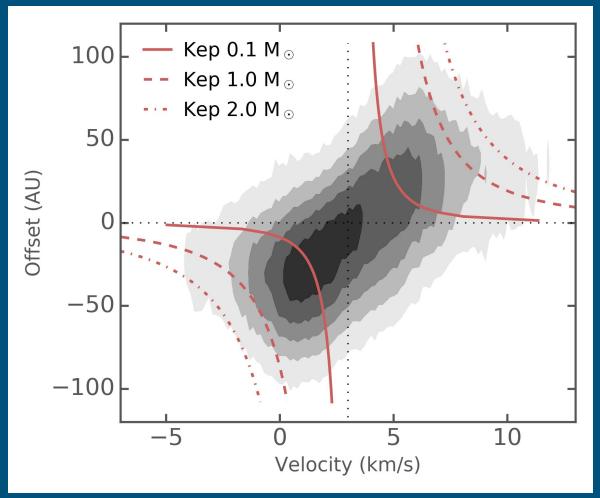
Free-fall



Infall + Keplerian (r_c=52 AU)



Keplerian



r_c from Favre+14

Should follow emission at edges (the 3σ contour) well, Infall+Keplerian do this slightly better than the pure free-fall and pure Keplerian. Difficult to constrain from analysis in PV-diagram only.

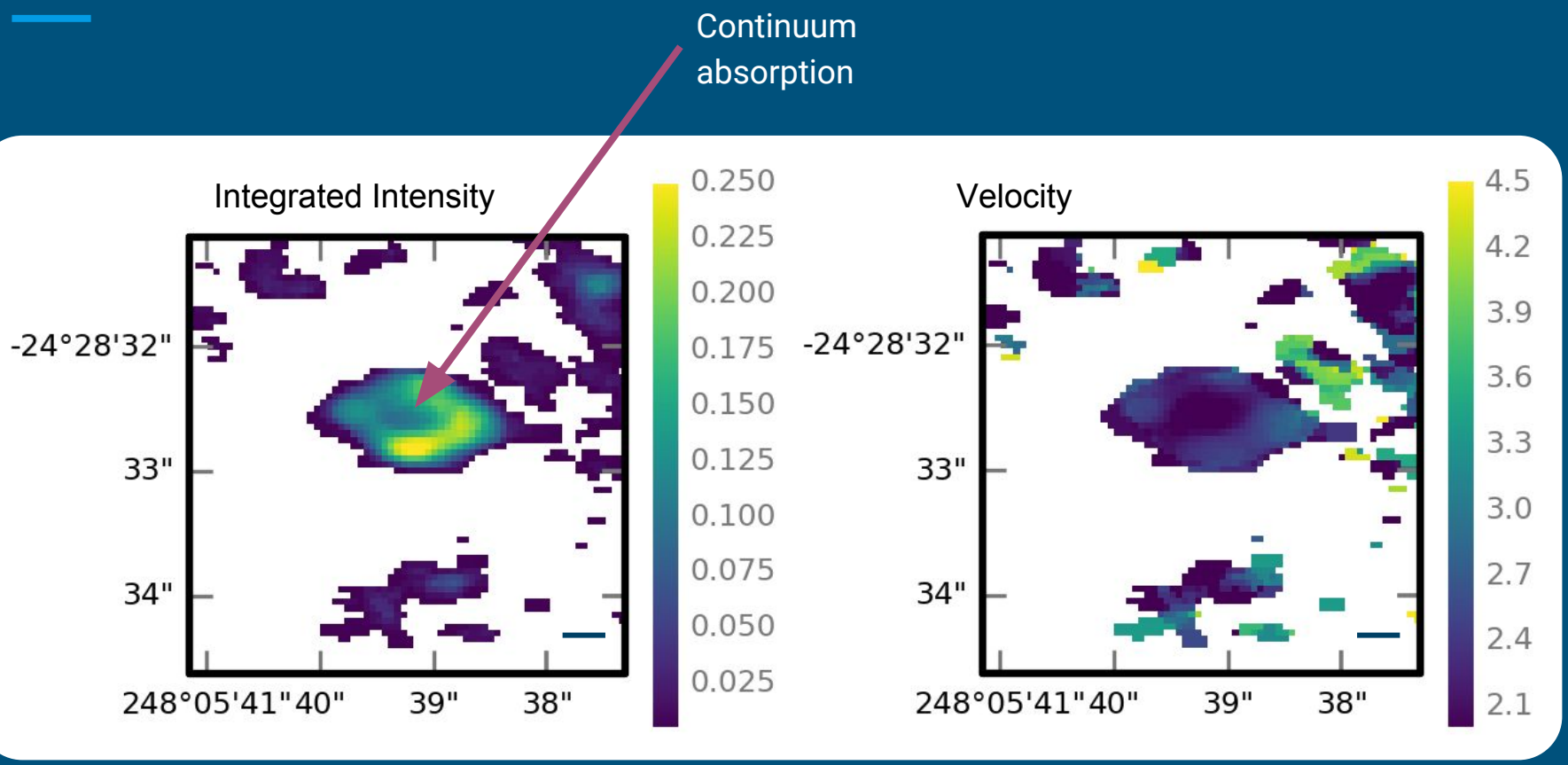
IRAS 16293-2422 A - Kinematics of water

Ongoing work

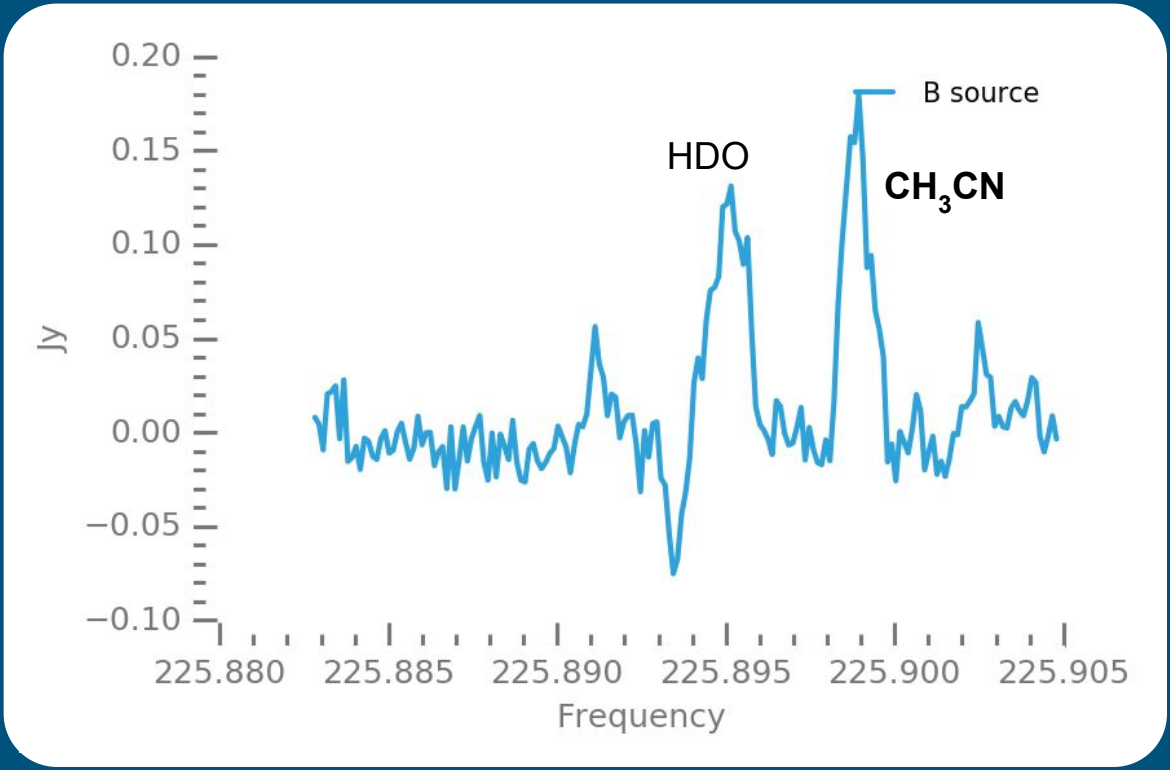
Currently constructing thin disk models of the kinematics (intensity models) to see if we can distinguish between these scenarios.

(Have additional ALMA data of $C^{34}S$ at 0.5" (ACA+12m) might help constrain kinematics.)

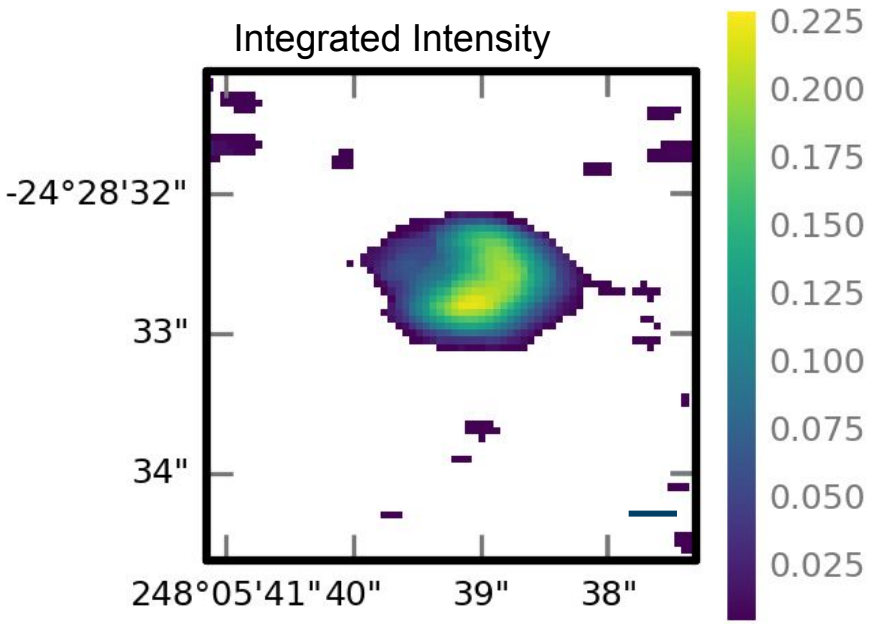
IRAS 16293-2422 B - HDO

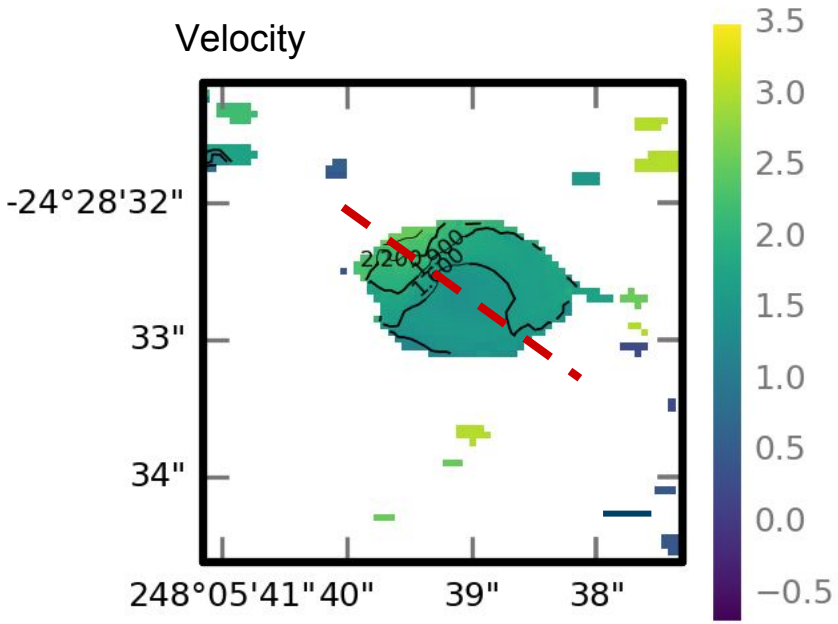


IRAS 16293-2422 B - CH_3CN



IRAS 16293-2422 B - CH_3CN





Source A

Velocity gradient in most lines, incl. HDO, perpendicular to main outflow on ~100 AU scale.

Compact inclined rotating structure.

Analysis ongoing.

Source B

No clear gradient in HDO.
Faint gradient in CH_3CN.

Thank you.