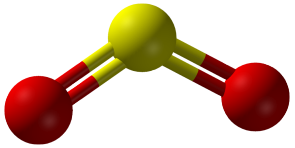
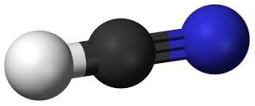
Chemical Complexity of AFGL 2591

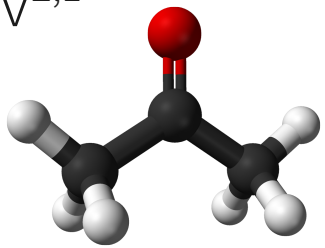
Caroline Gieser[1], Henrik Beuther[1], Dmitry Semenov[2,1]

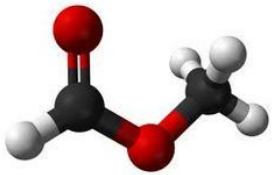
[1]*Max Planck Institute for Astronomy, Heidelberg*

[2]*Ludwig Maximilian University of Munich*



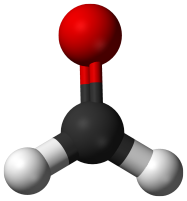


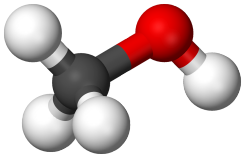


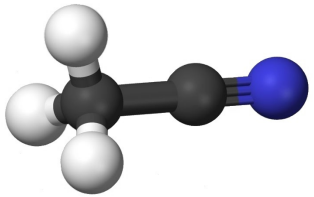


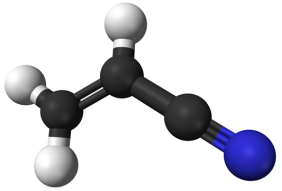
Wonders of Star Formation, Edinburgh

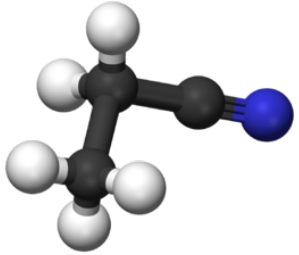
September 03, 2018

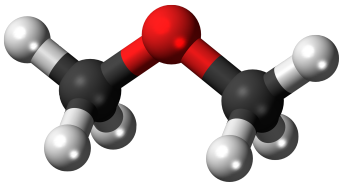




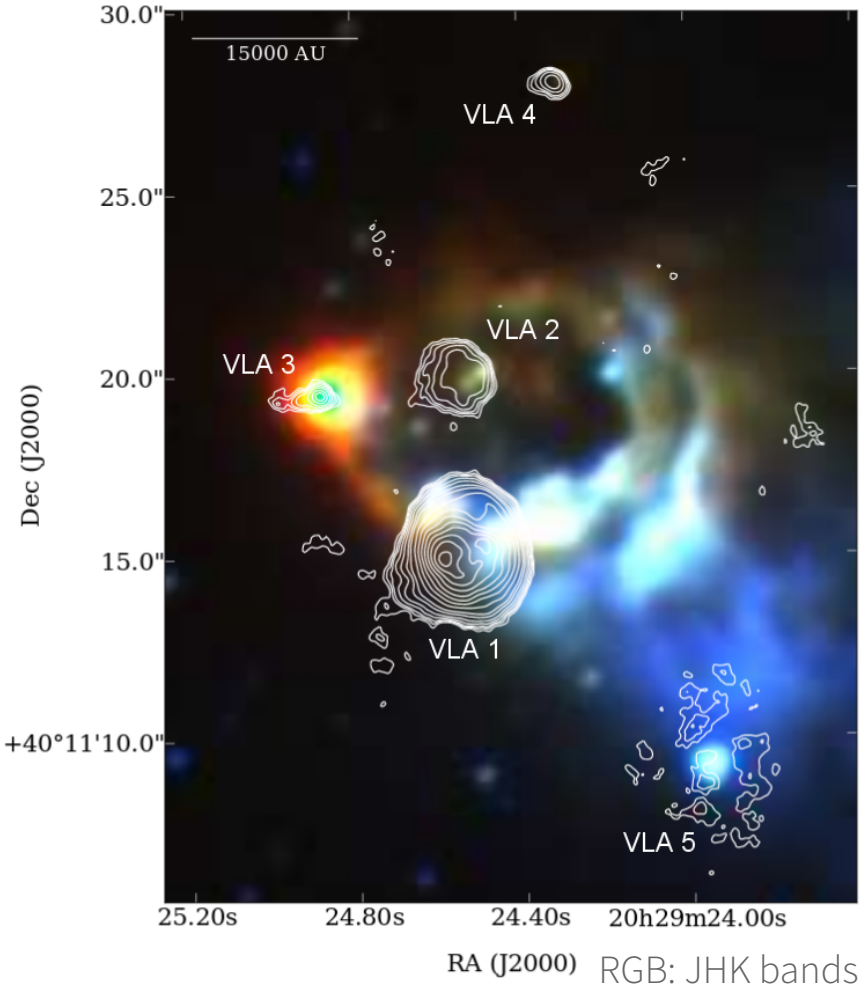








Introduction: The AFGL 2591 star-forming region



Johnston et al. (2013)

RGB: JHK bands
contours: 3 cm continuum

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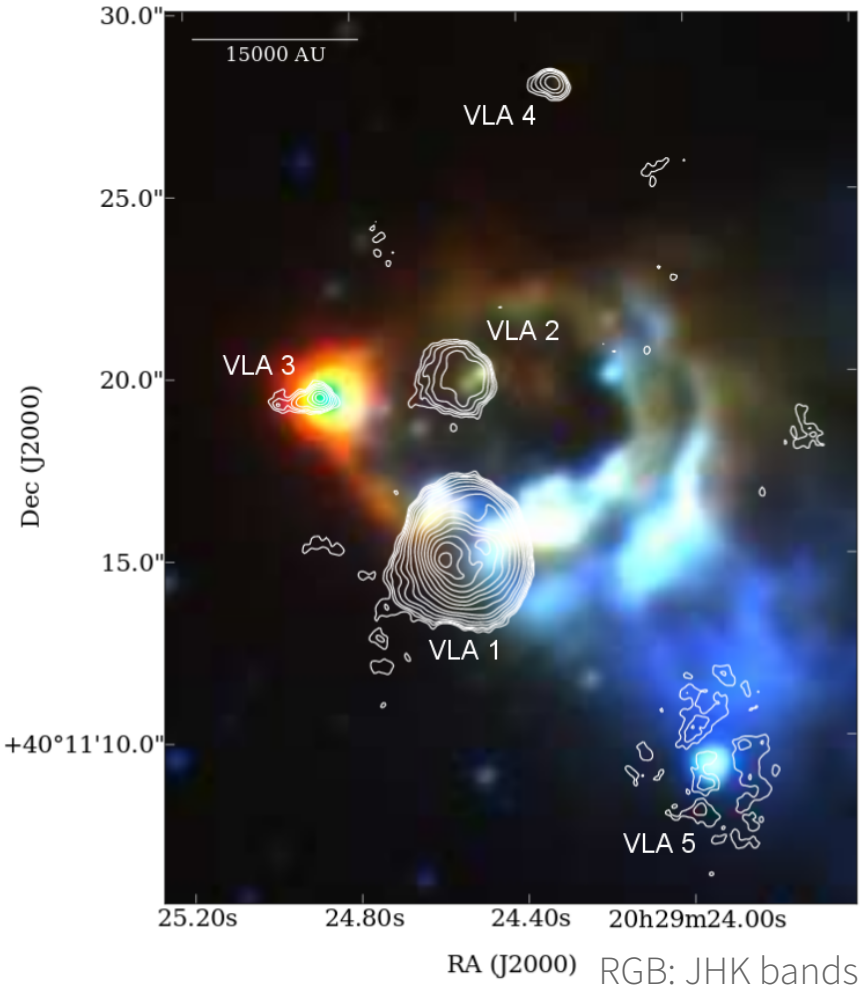

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VLA 3 hot core:

$L = 5 \times 10^5 \, L_\odot$ & $M = 40 \, M_\odot$ (Sanna et al. 2012)

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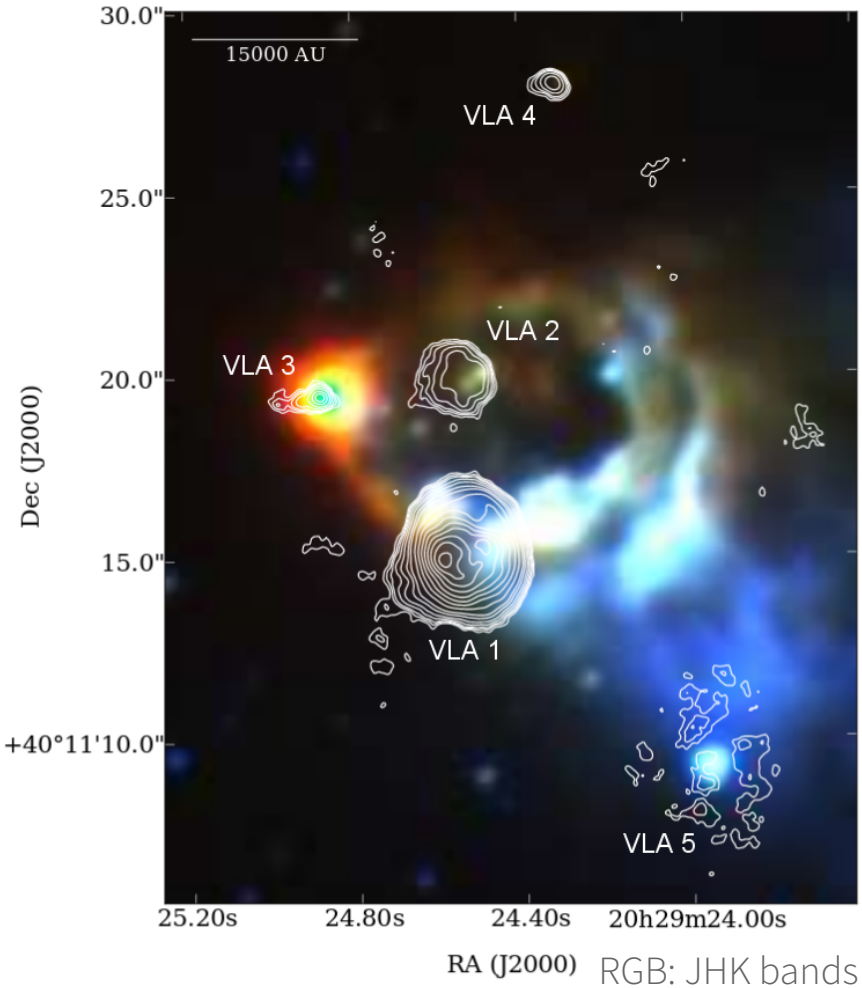

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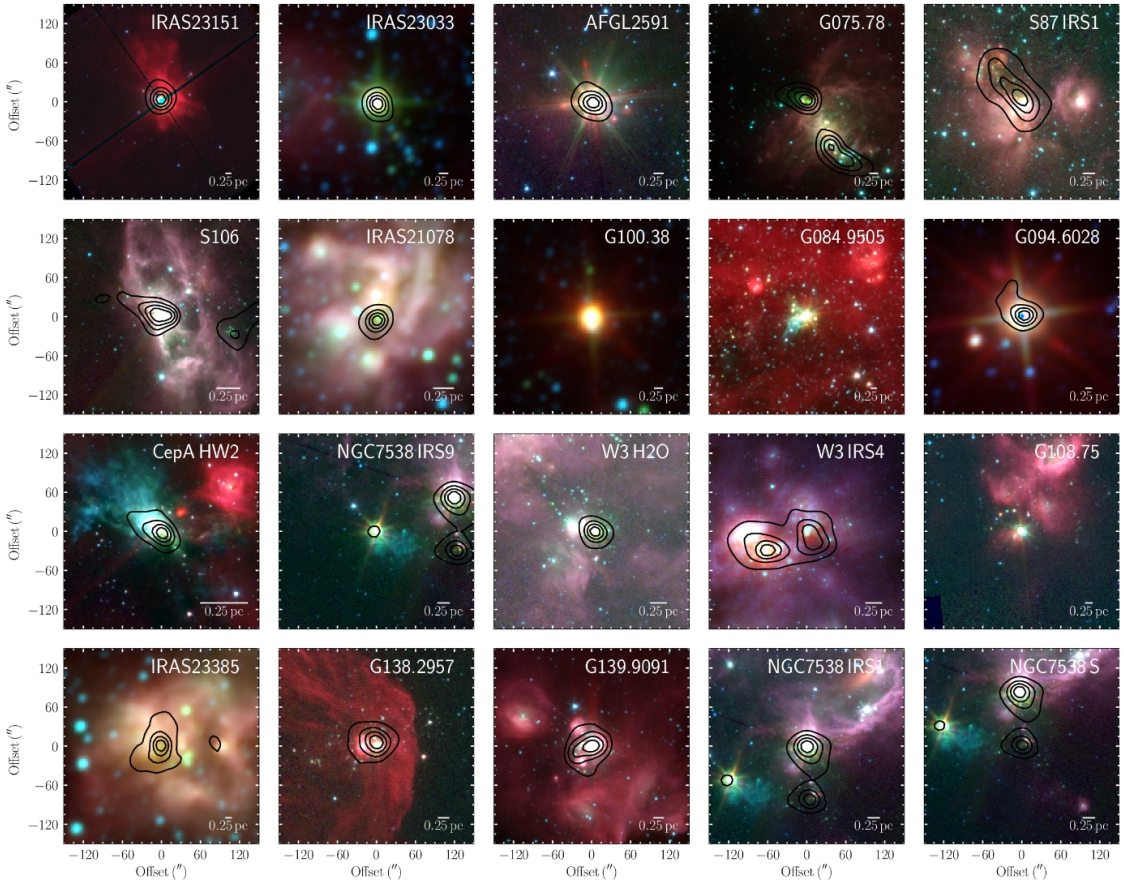
$\tau \approx 5\times10^4$ years (Kaźmierczak-Barthel et al. 2015)

Spatial chemical segregation:

- Single peak (e.g., H_2S, CS)
- Double peak (e.g., HC_3N, OCS, SO, SO_2)
- Ring like structure (e.g., CH_3OH)

(Jiménez-Serra et al. 2012)

Introduction: The CORE Project



RGB: IR observations
contours: 850 µm continuum

Beuther et al. (2018)

➔*"Fragmentation and disk formation in high-mass star formation"* Talk by Henrik Beuther on Friday

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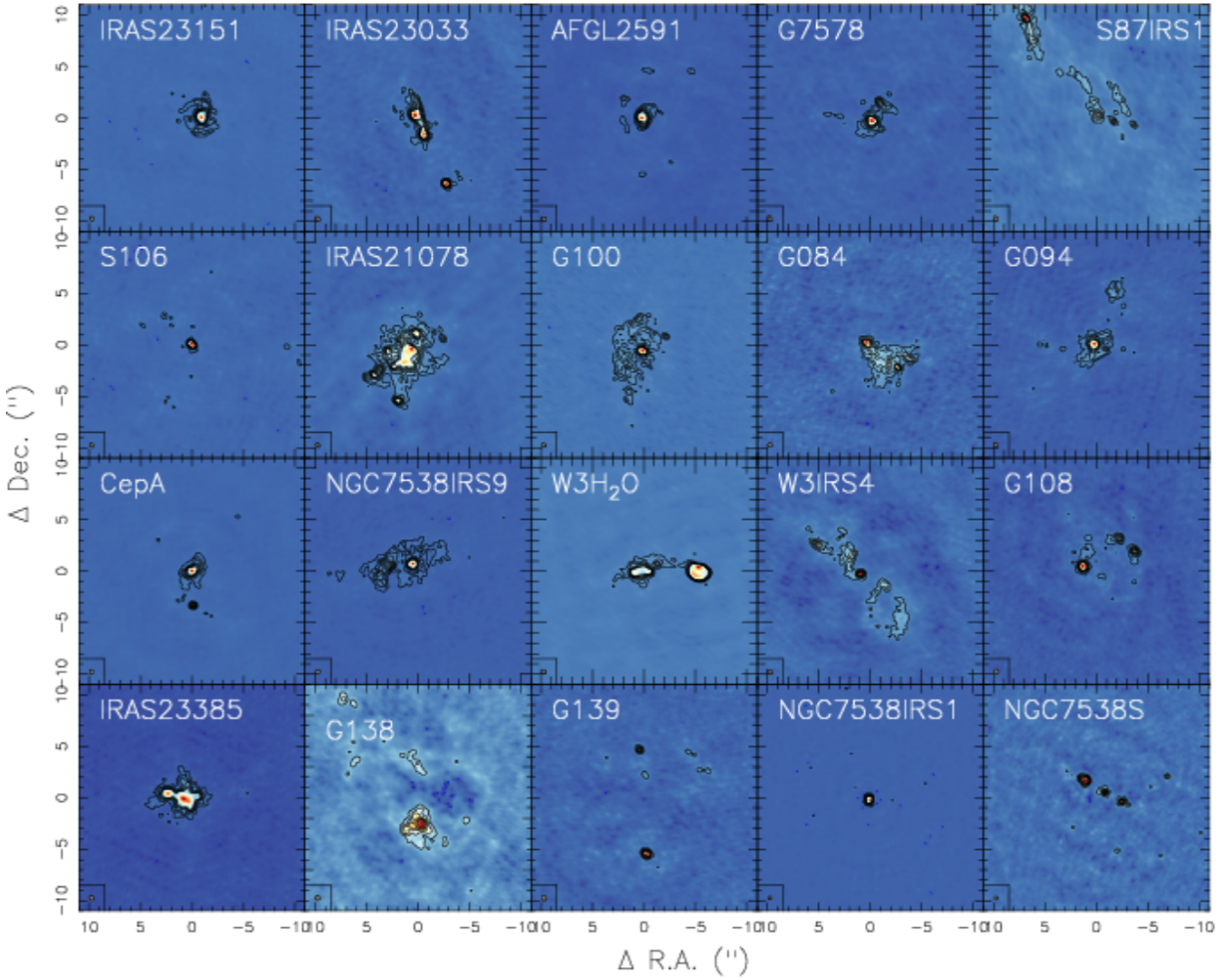

1 mm continuum

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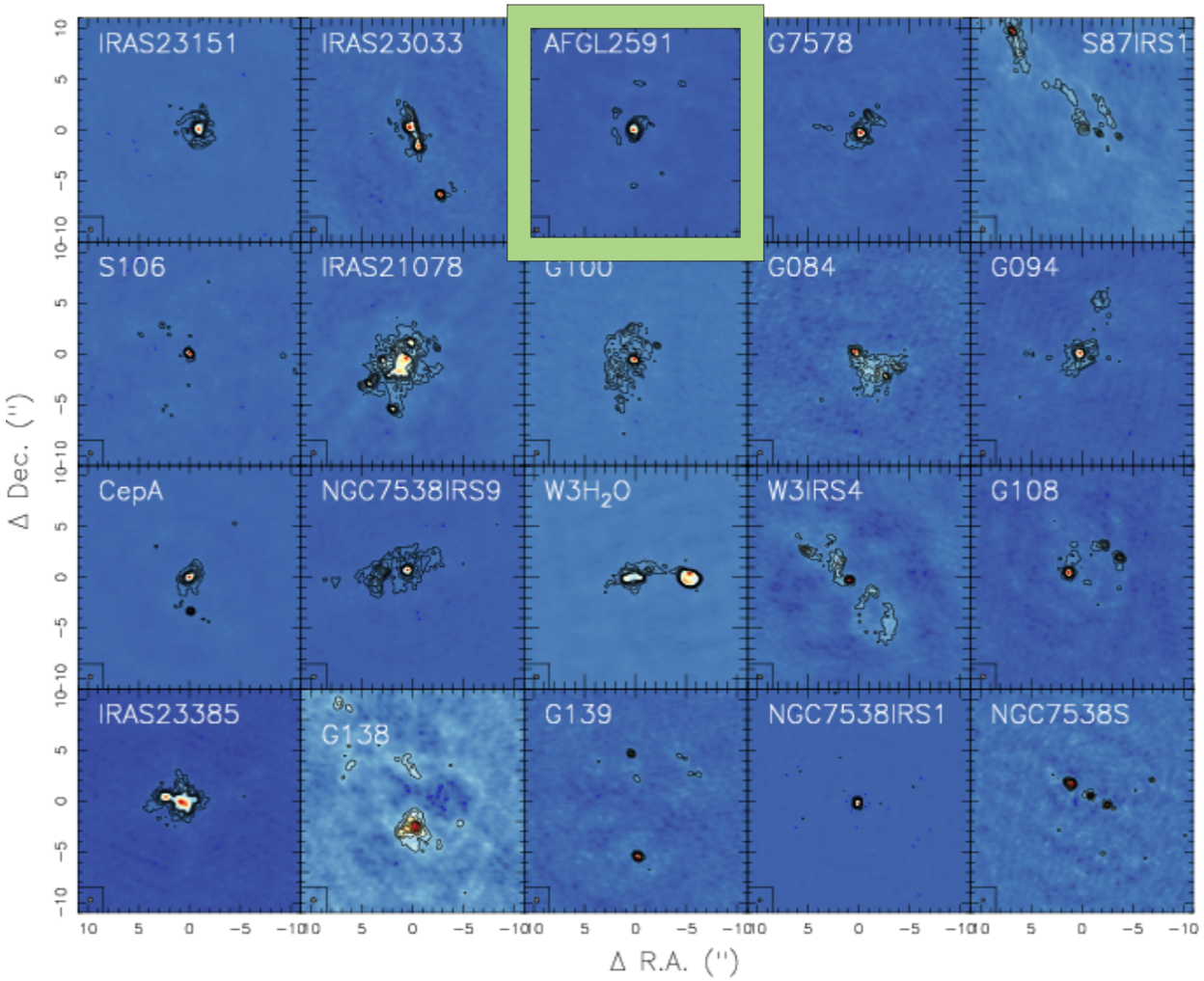

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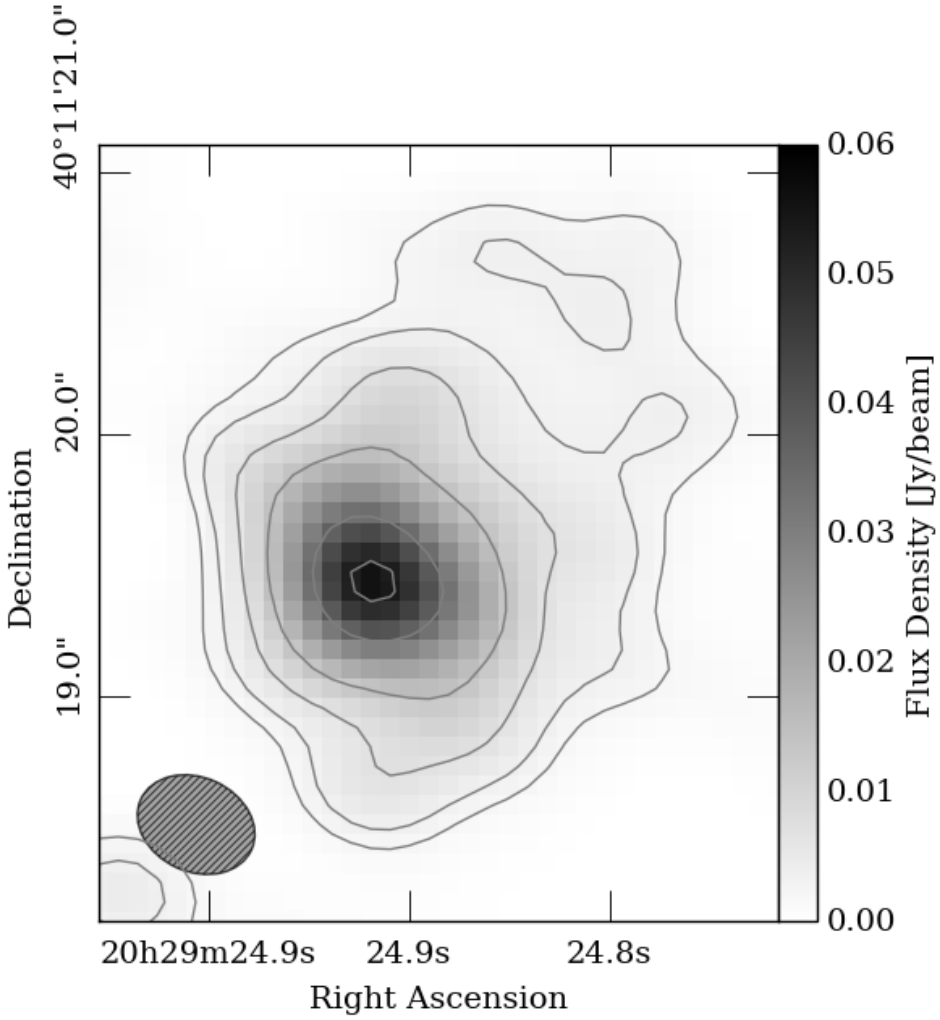
Analysis: 1.37 mm continuum emission



Gieser et al. (in prep.)

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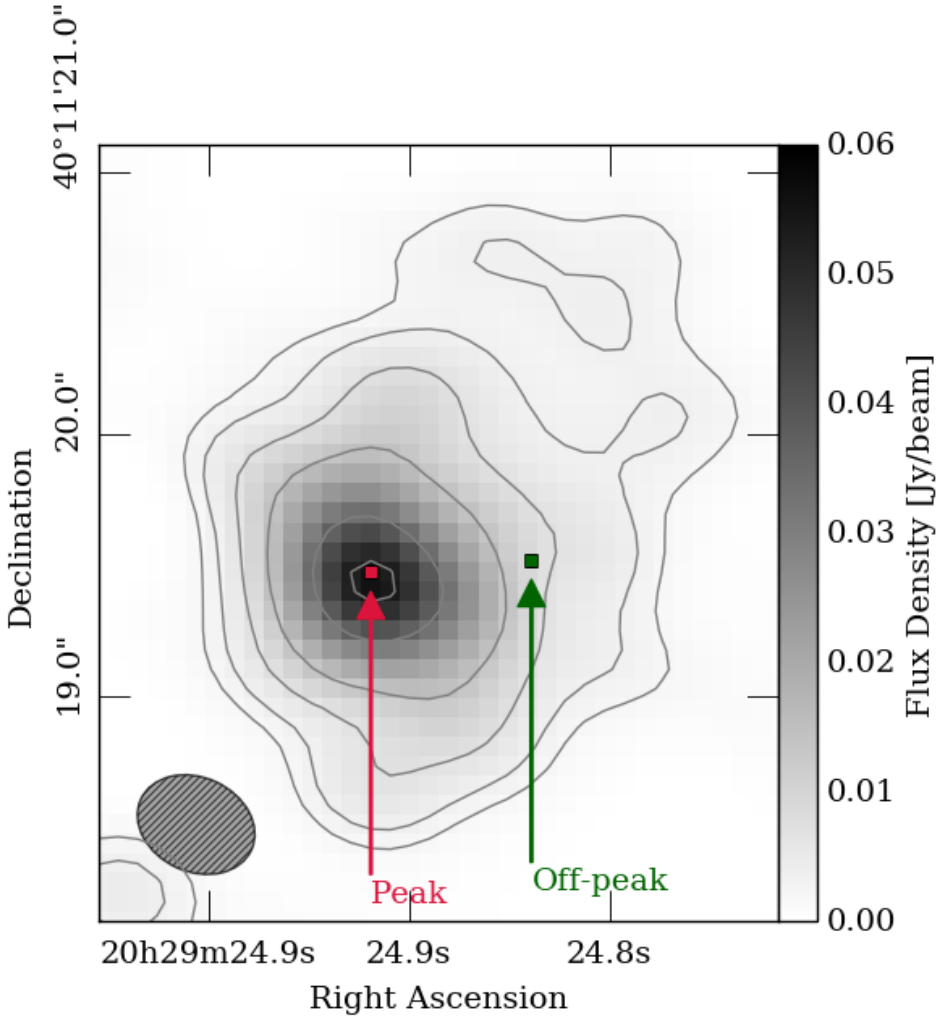

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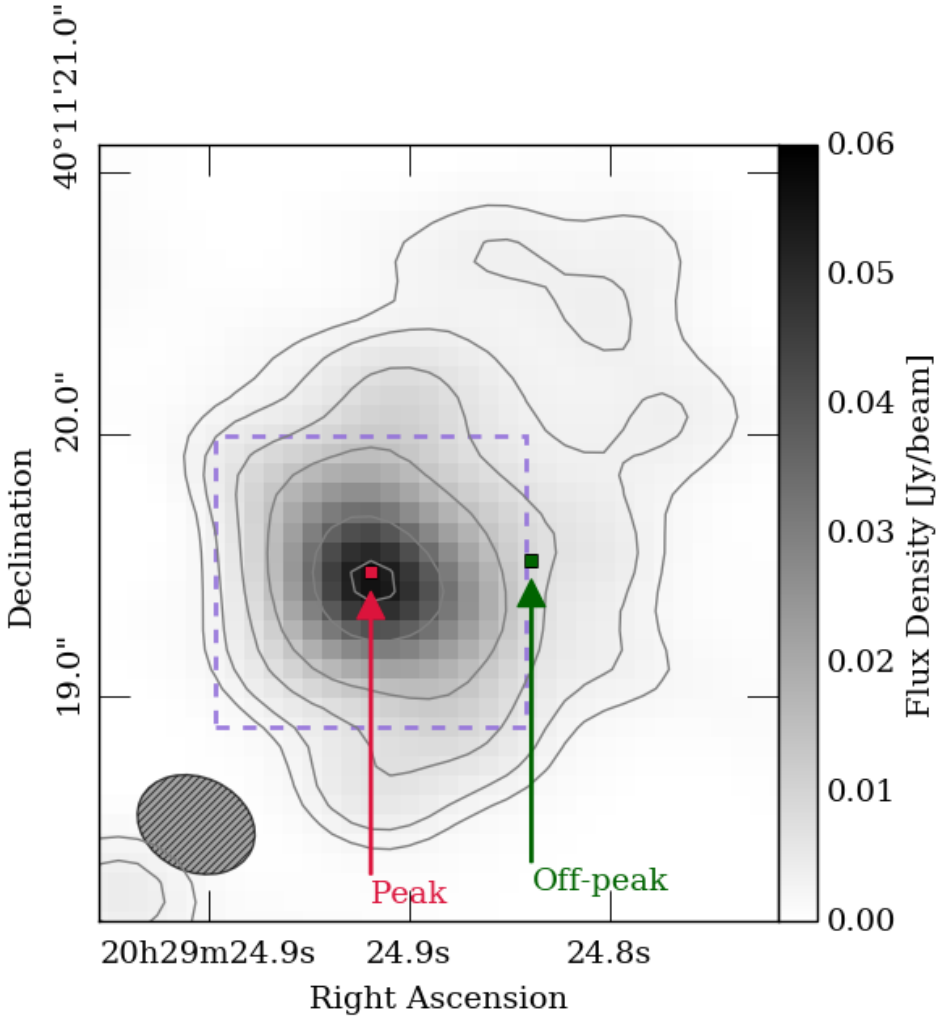

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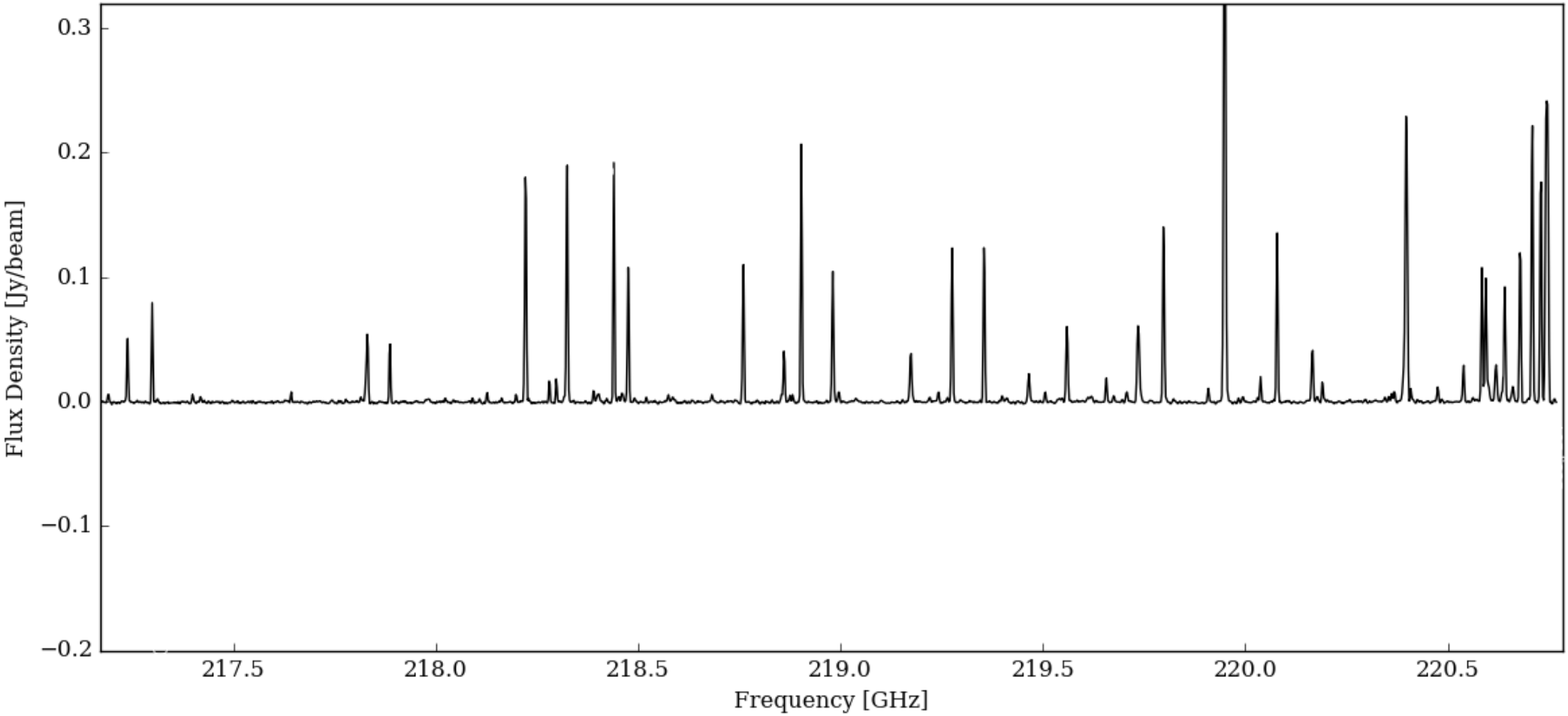

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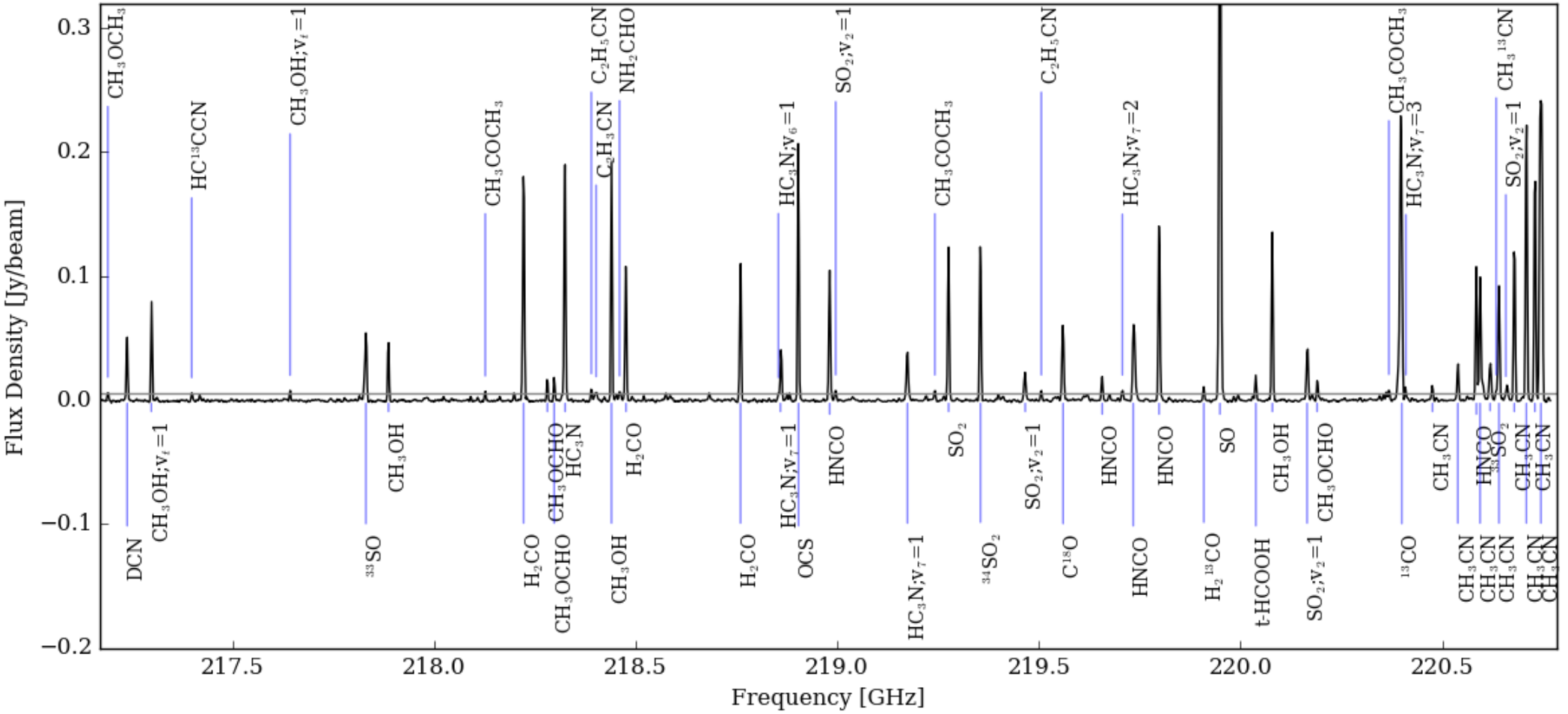

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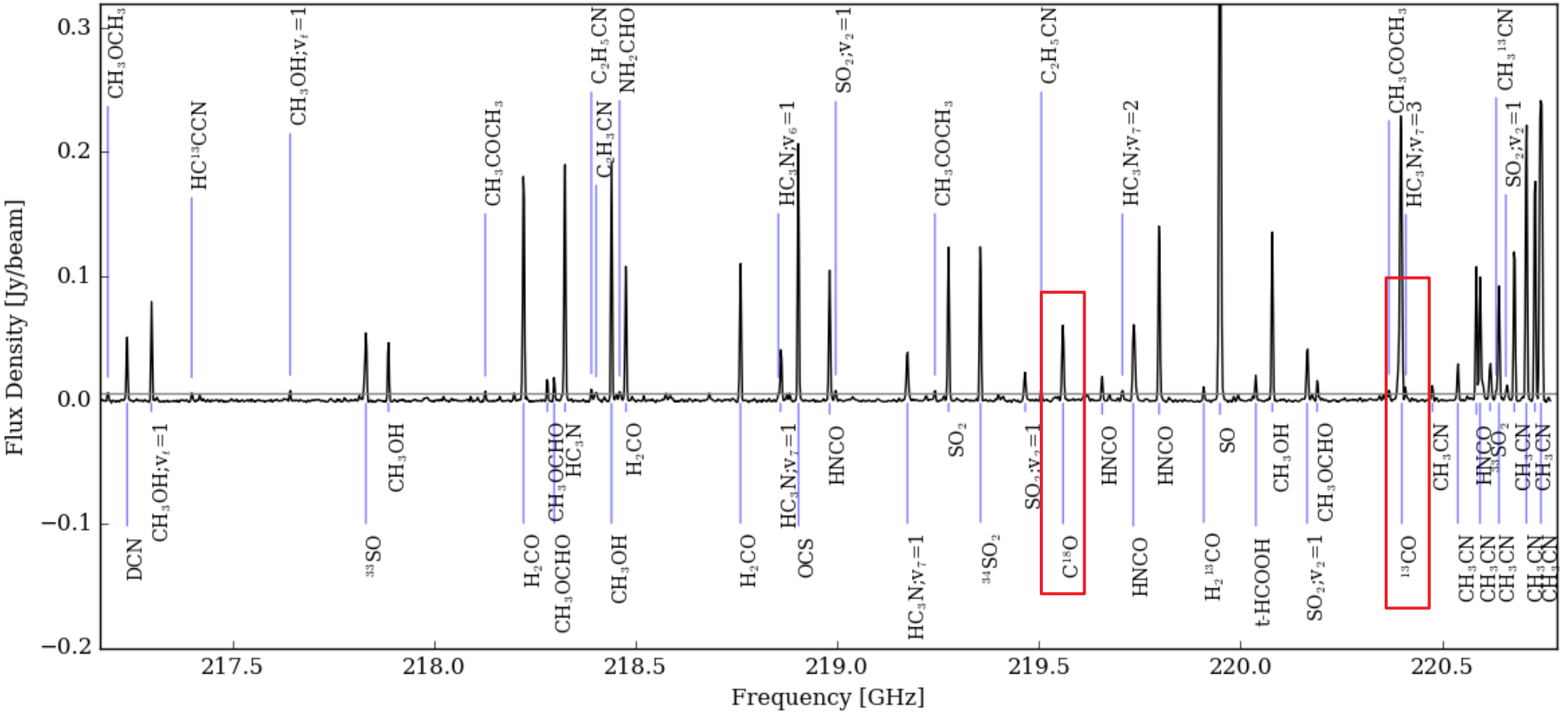

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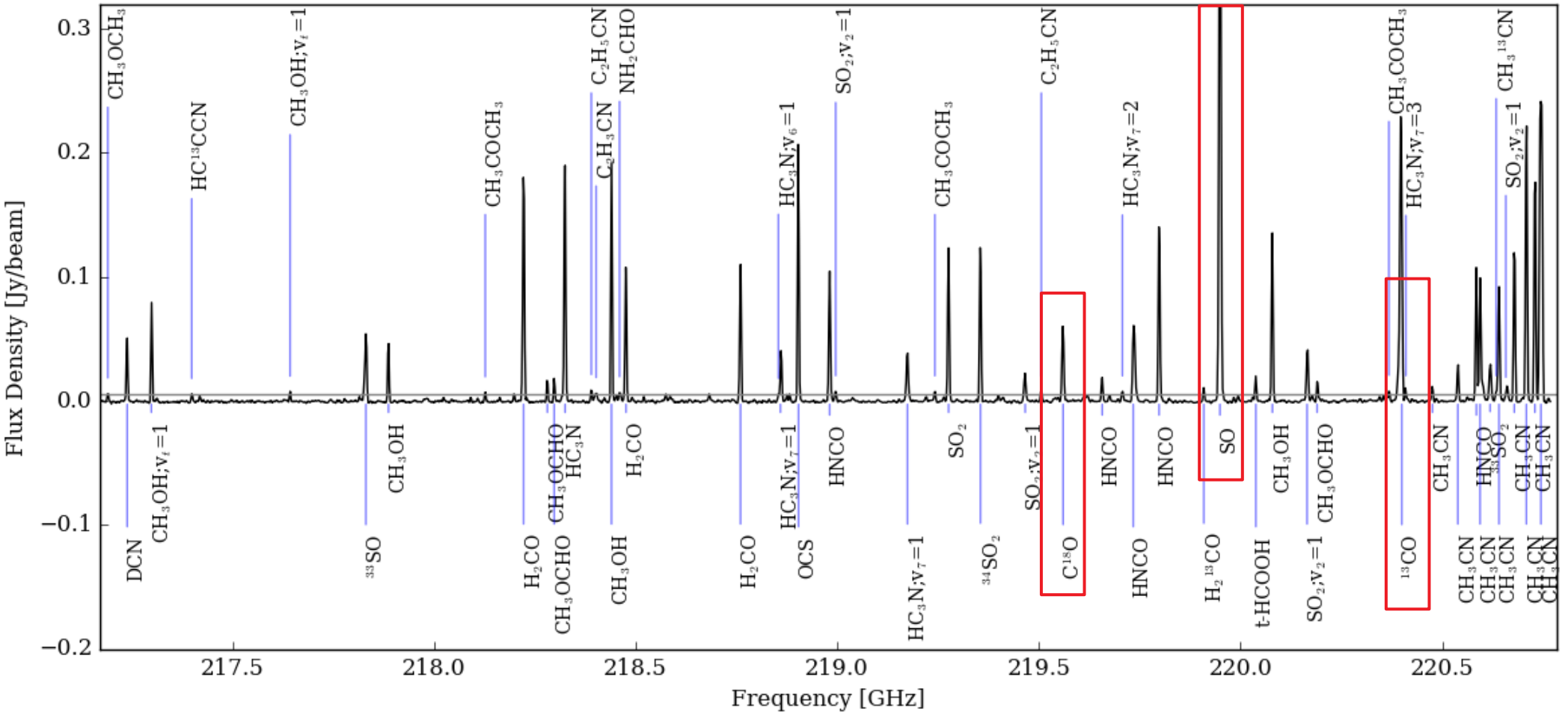

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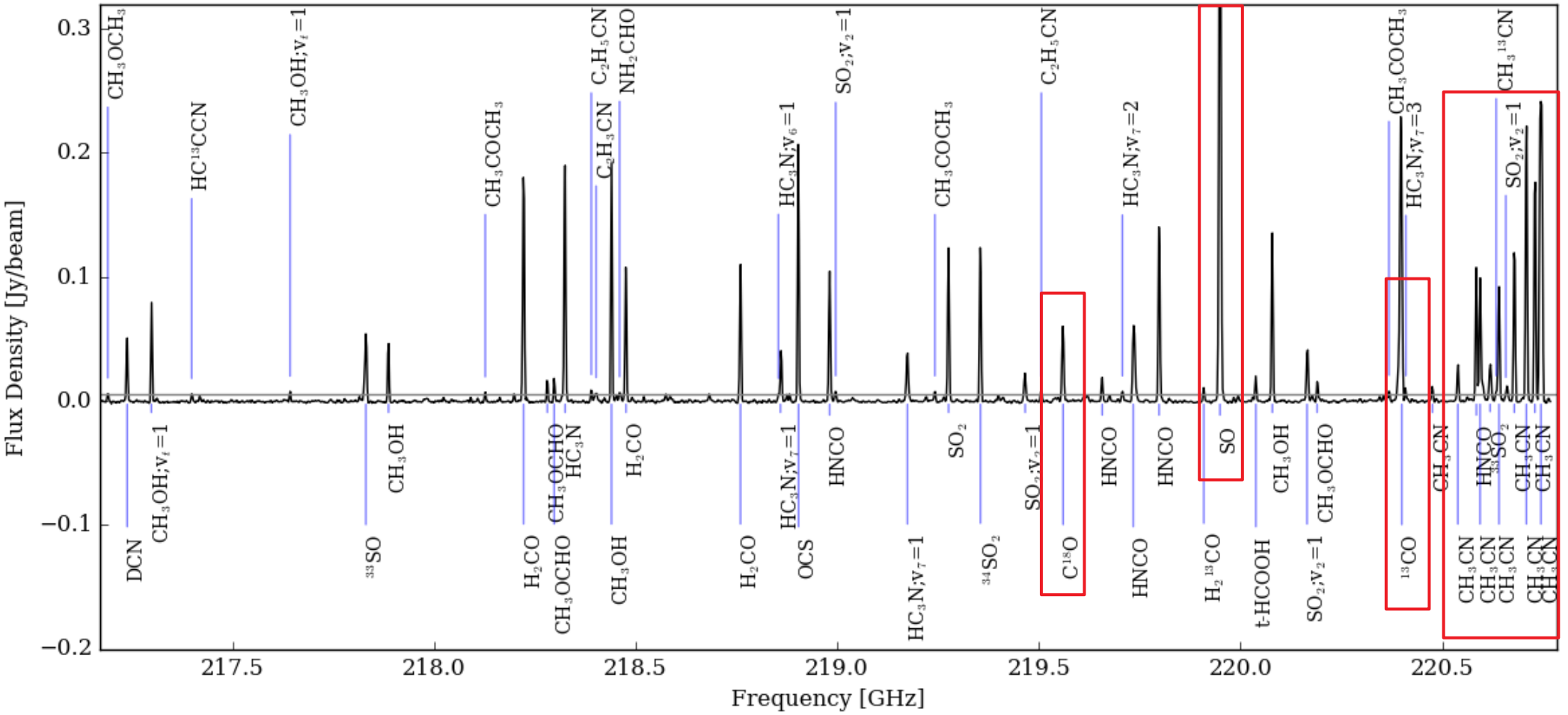

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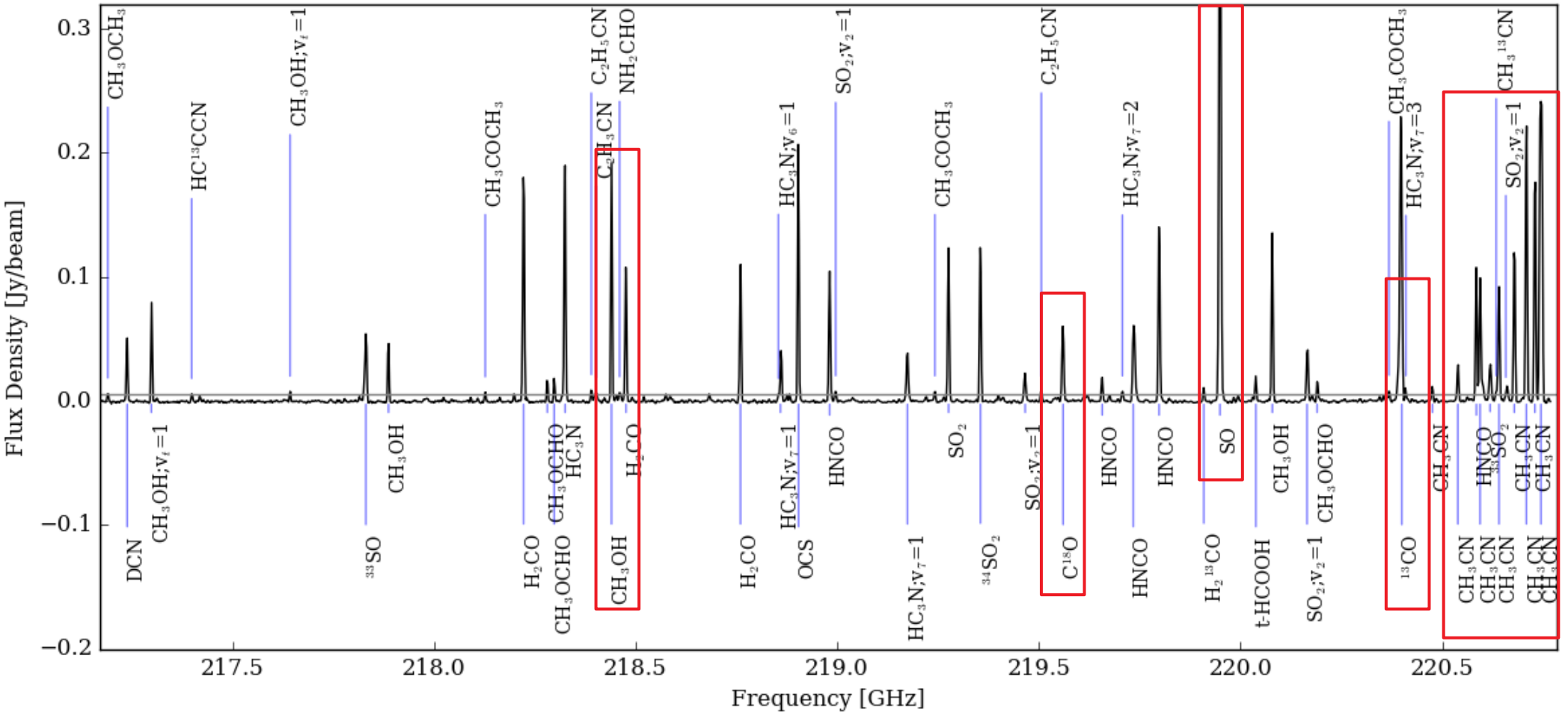

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Analysis: Temperature and Column Density Determination

XCLASS (Möller et al., 2017): LTE radiative transfer of an isothermal source

- ➔ determine temperature, column density, line width and velocity offset
- ➔ fitting procedure is highly degenerate if only a few lines are present

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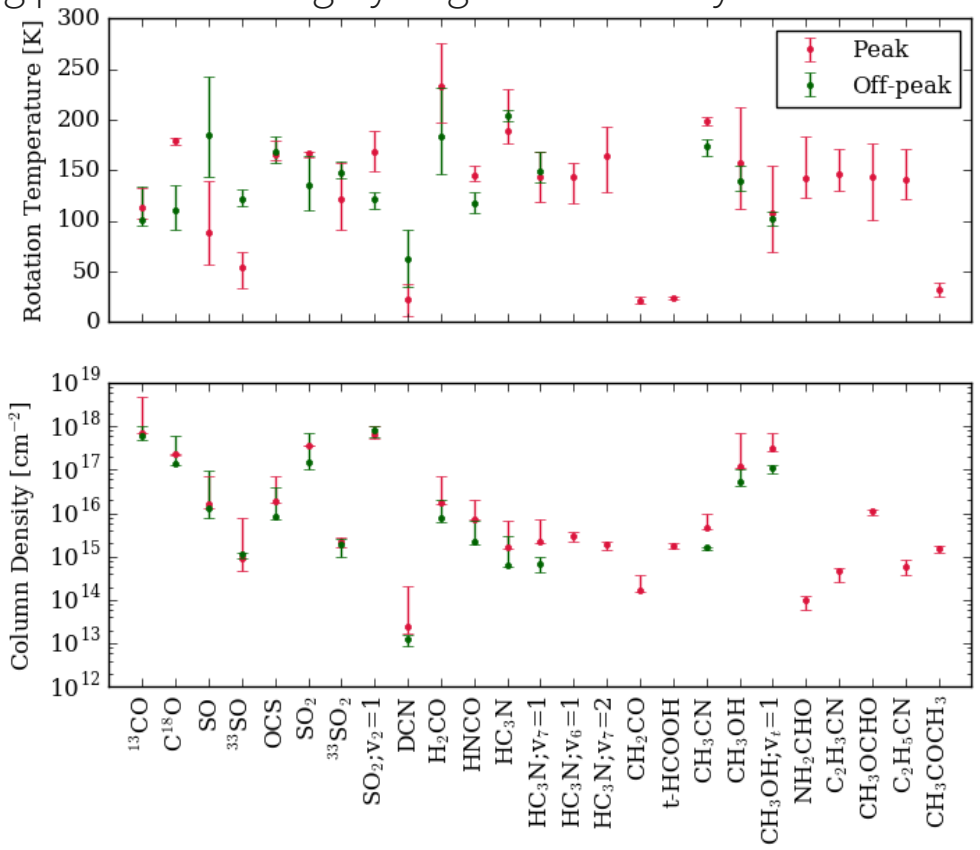

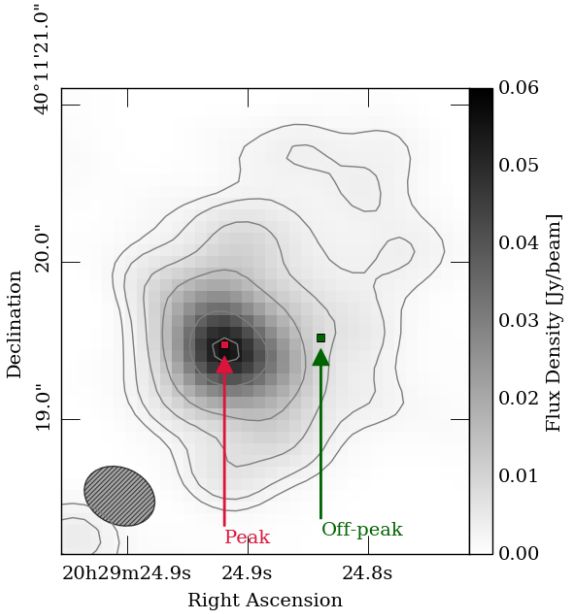

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Model: MUSCLE (MUlti Stage ChemicaL codE)

Semenov et al. (2010):

Chemical evolution at several stages during high-mass star formation

(IRDC – HMPO – HMC – UCHII; see Gerner et al. 2014, 2015)

Physical model:

$$n(r) = n_0 \qquad r < r_{\rm in}$$

$$n(r) = n_0 \left(\frac{r}{r_{\rm in}}\right)^{-p} \qquad r \geq r_{\rm in}$$

p ≈1 - 2

$$T(r) = T_0 \qquad r < r_{\rm in}$$

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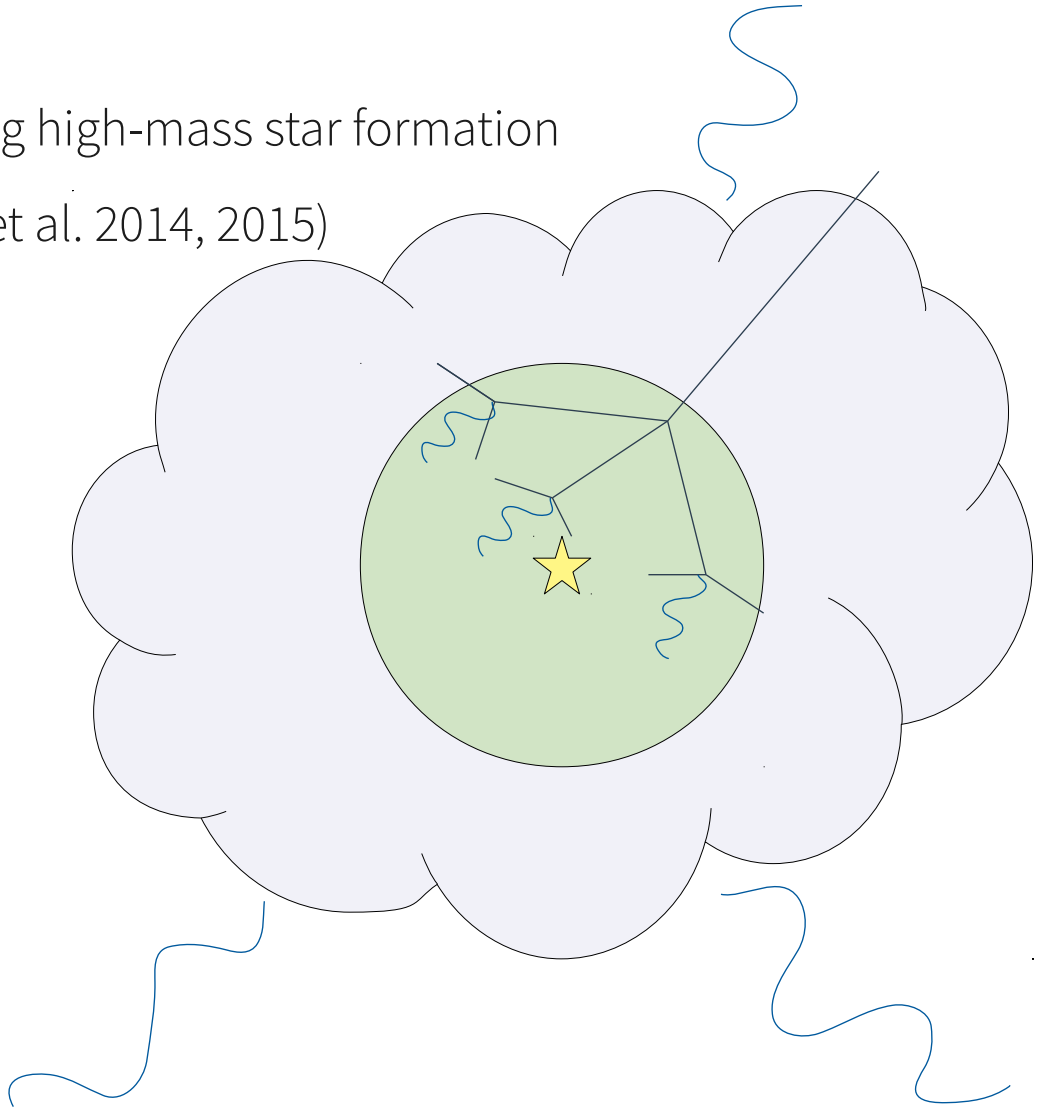
q ≈ 0.4



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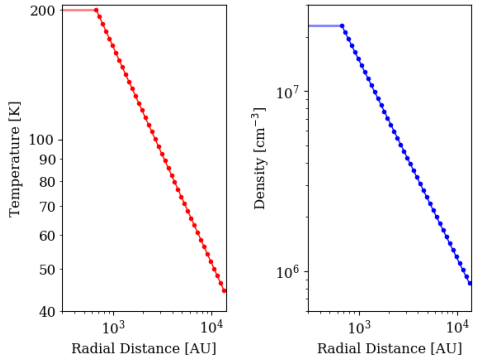
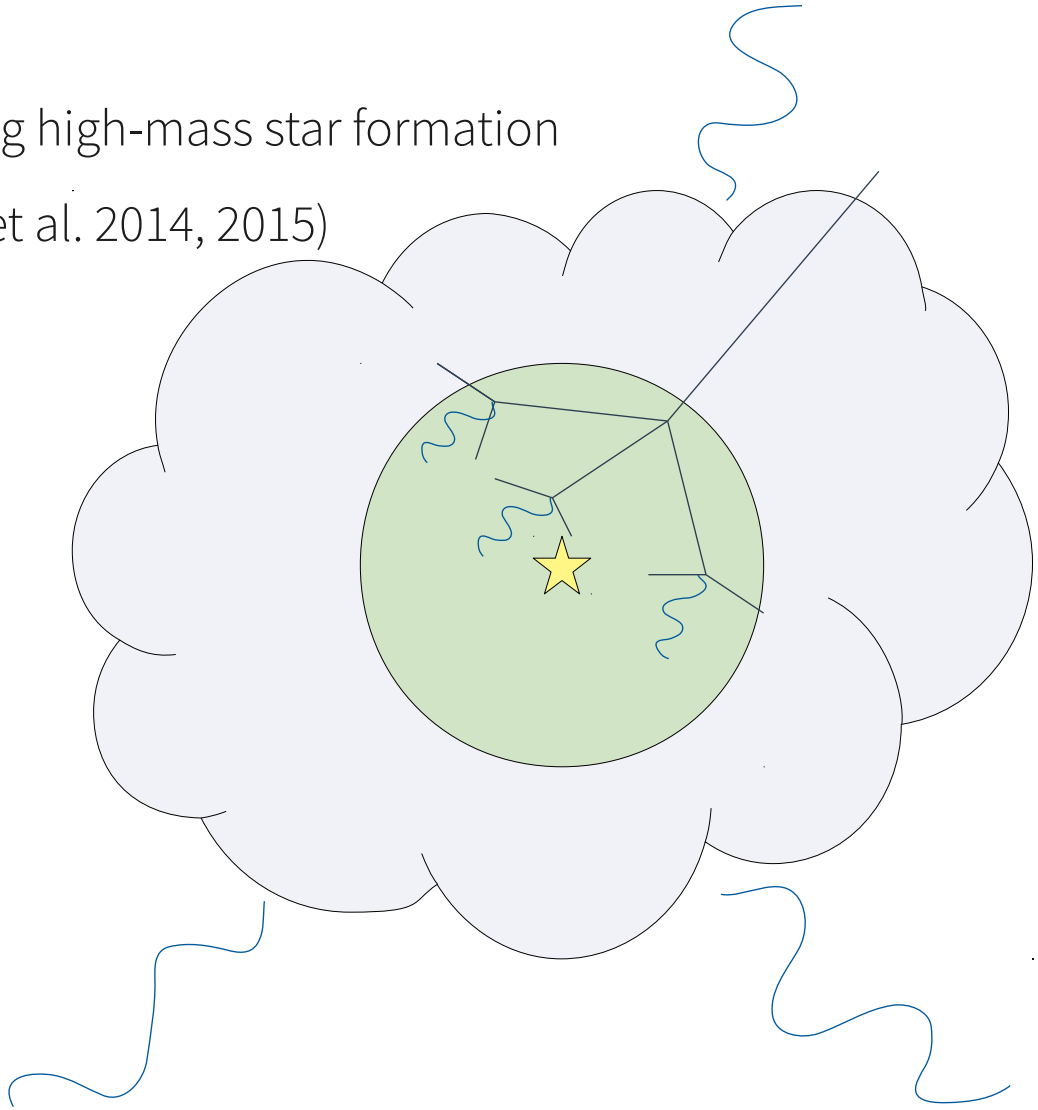


$p \approx 1 - 2$

$q \approx 0.4$



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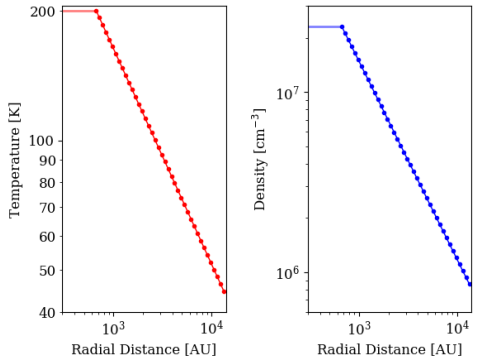

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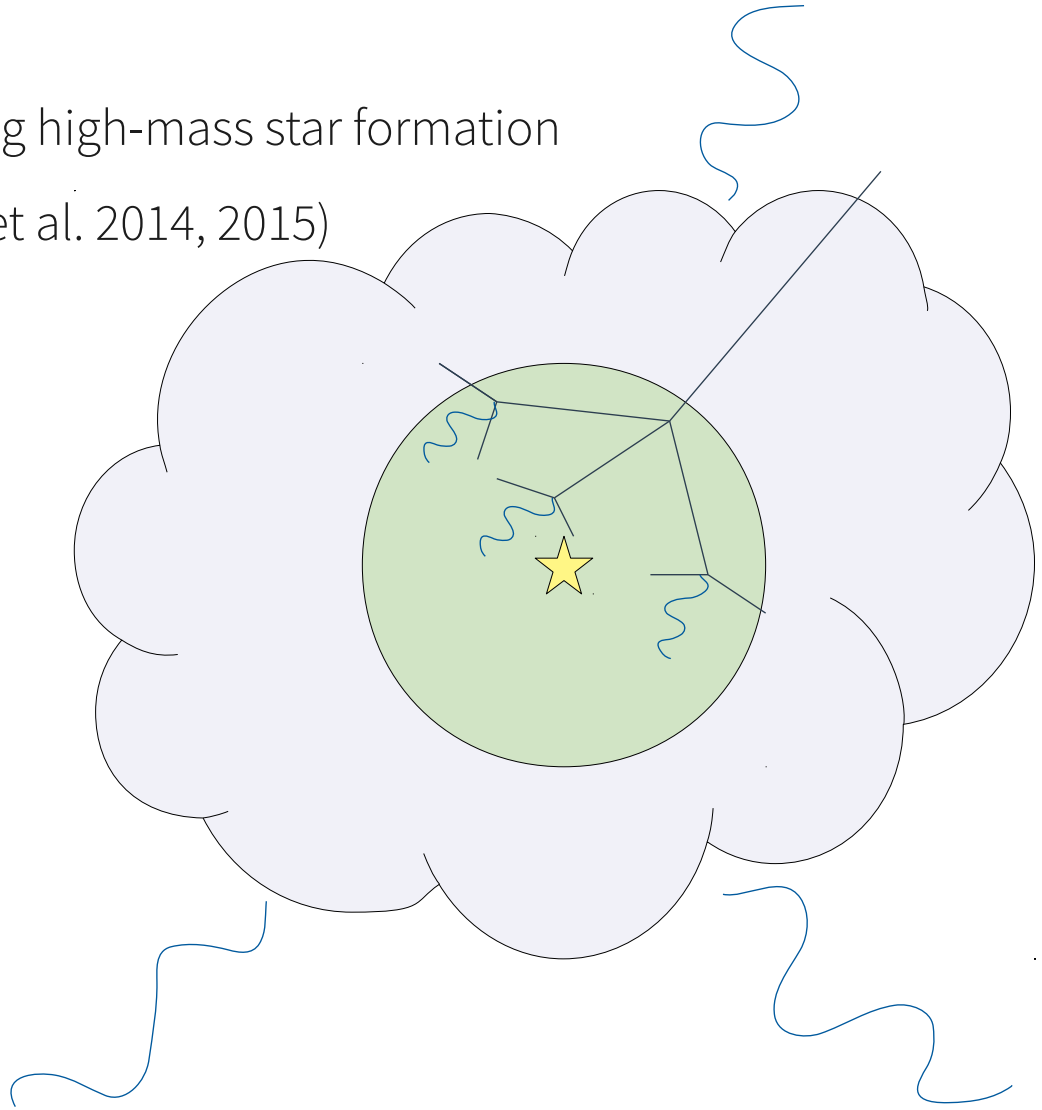

Chemical model:

ALCHEMIC

Grain-surface and gas-phase reactions

(taken from OSU and KIDA)

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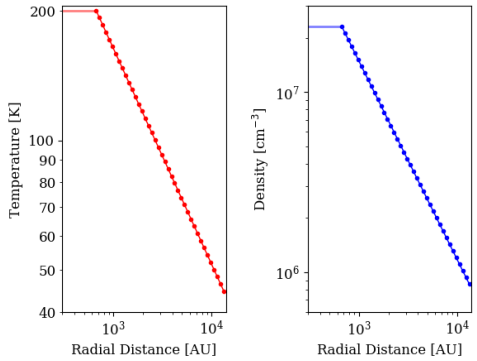

p ≈1 - 2

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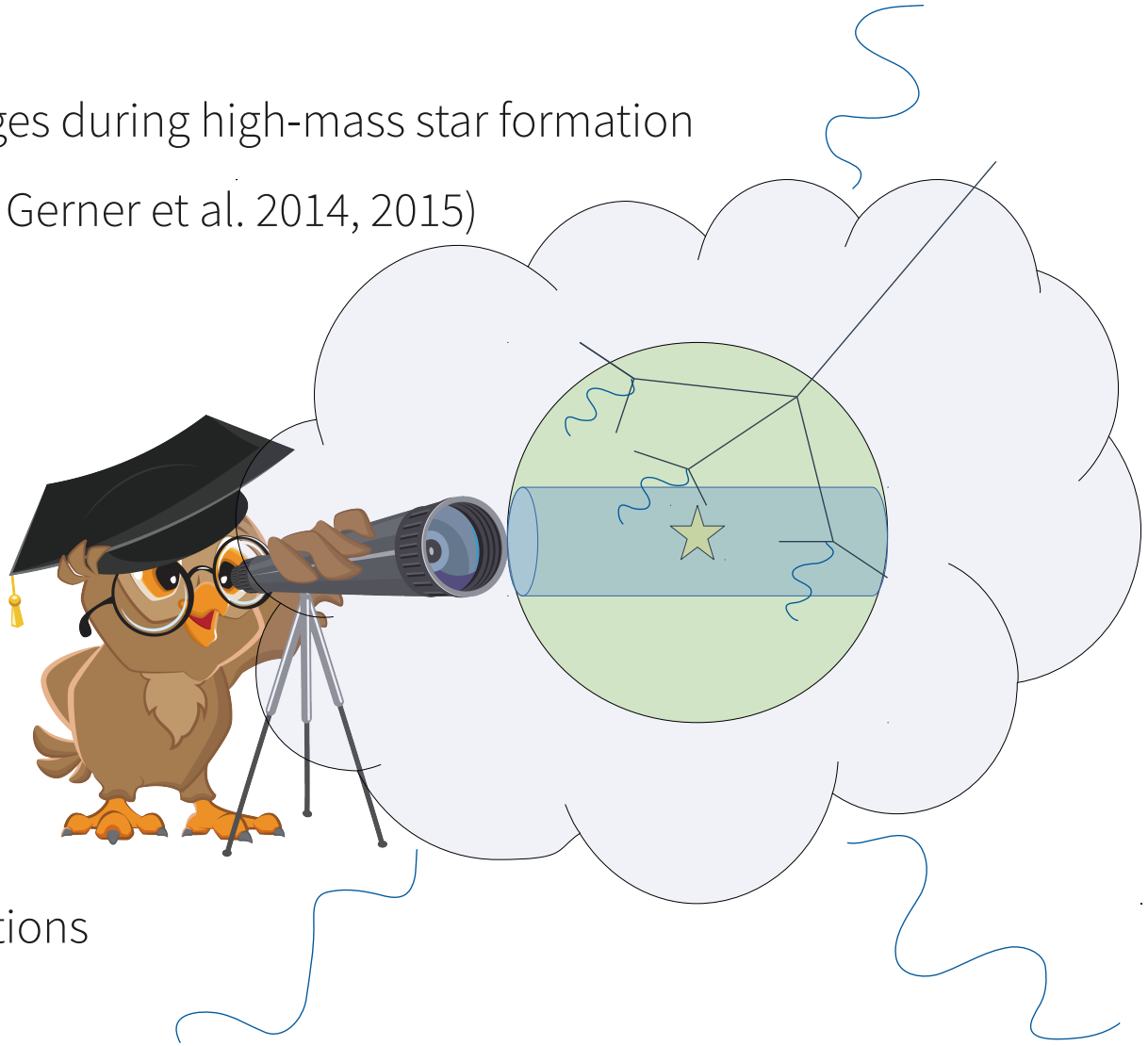

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Model: Results

Gieser et al. (in prep.)

Model: Results

Input:

r_{in} = 666 AU

T_0 = 200 K

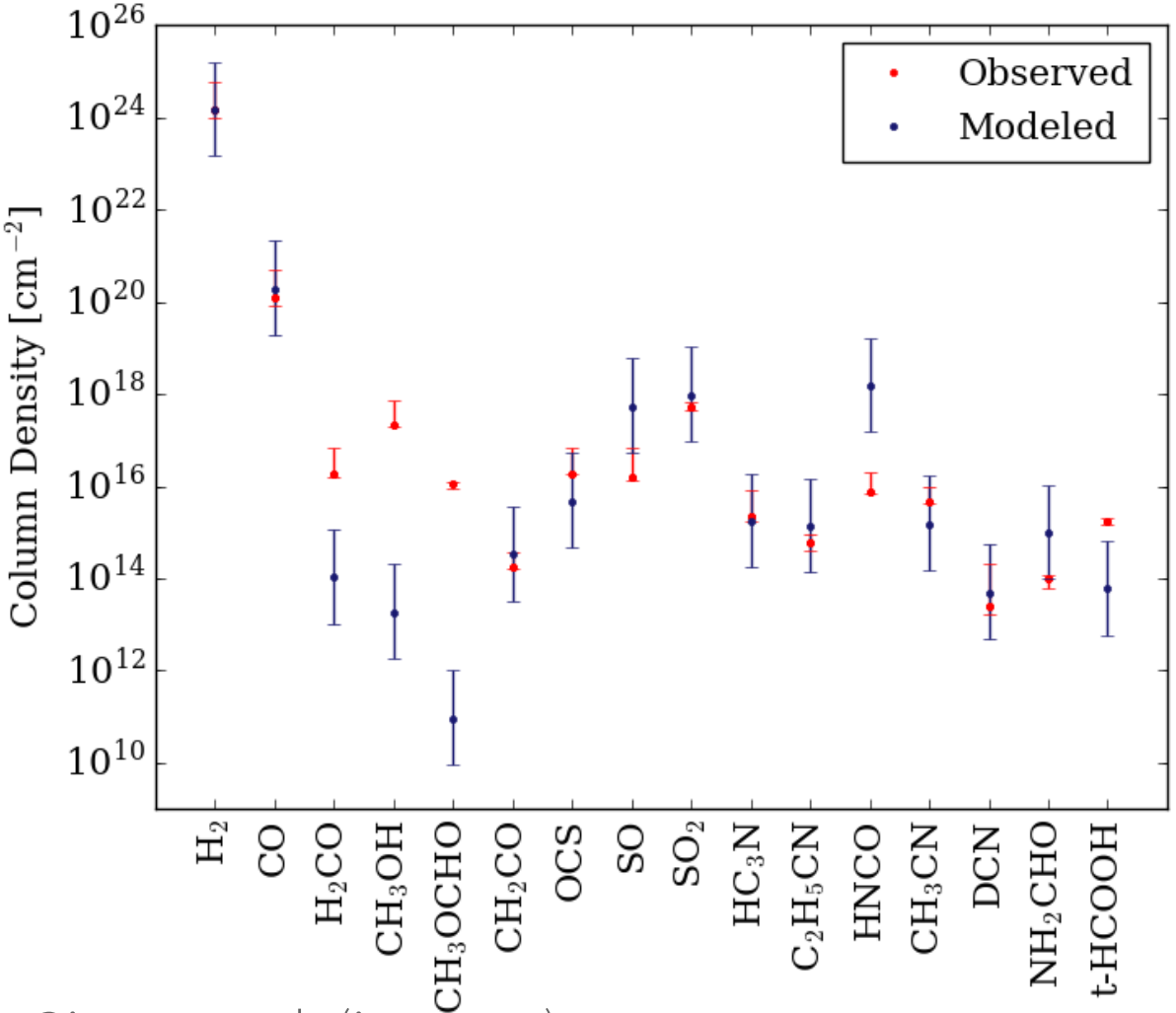
q = 0.5

r_{out} = 0.05 pc

Initial molecular abundances taken from Feng et al. (2016)

Gieser et al. (in prep.)

Model: Results



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Best fit:

τ = 33 430 years

p = 1.1

11 / 16 Molecules

Model: Radial Abundance Profiles and Time Evolution

Radial abundance profiles

at 33 430 years:

Time evolution

at 1329 AU:

Gieser et al. (in prep.)

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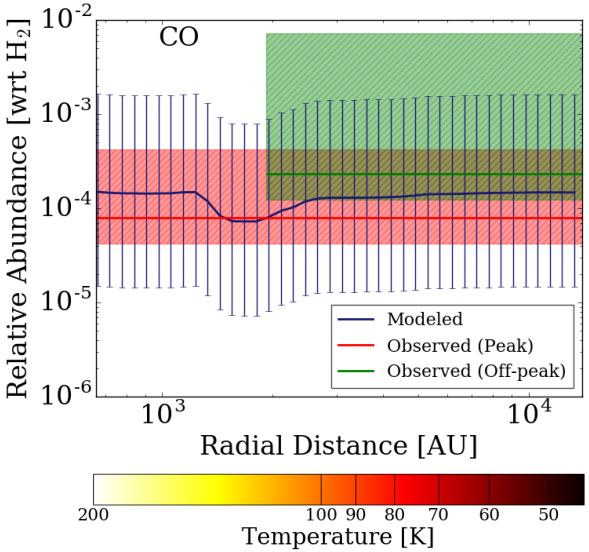

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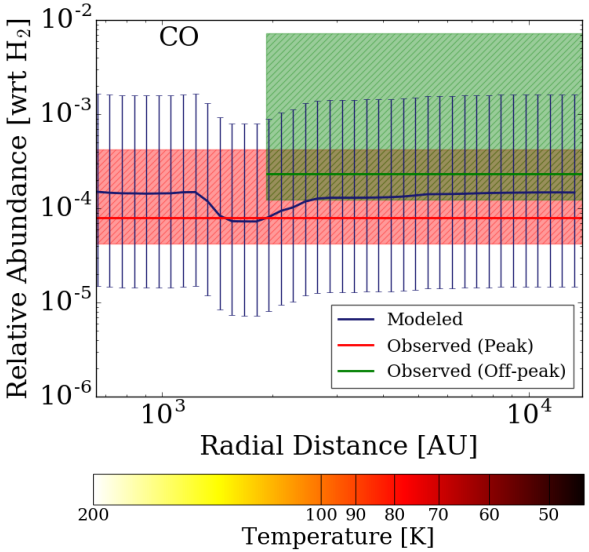

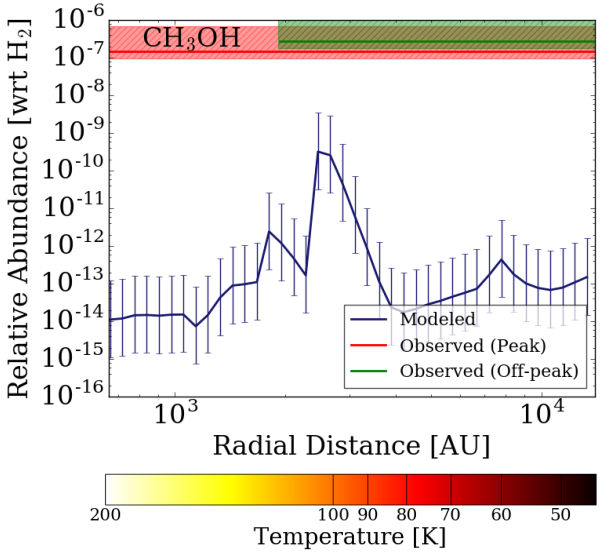

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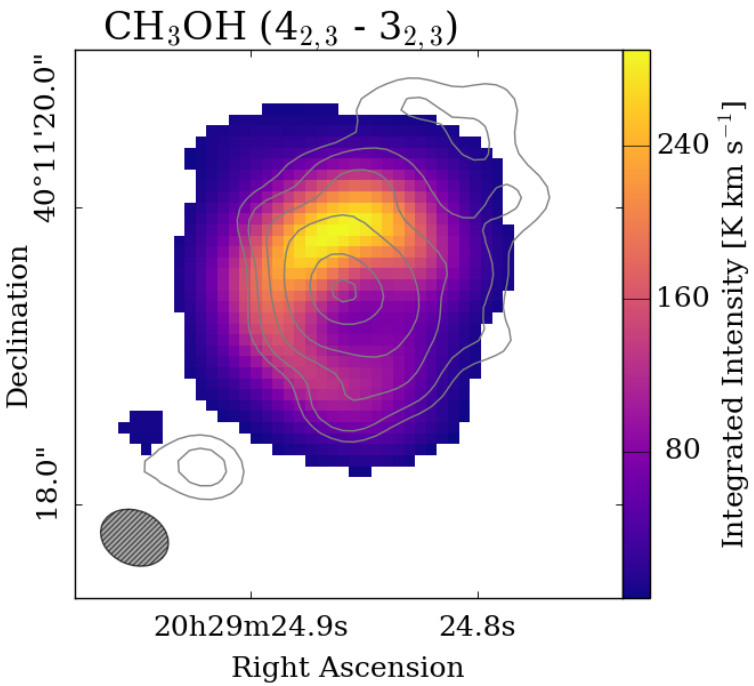

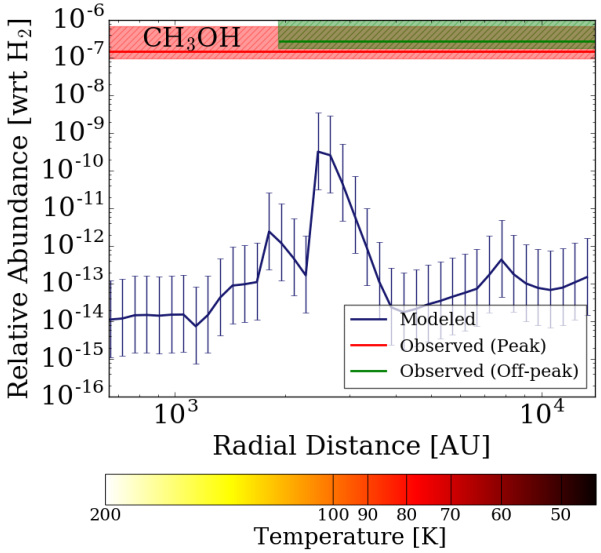

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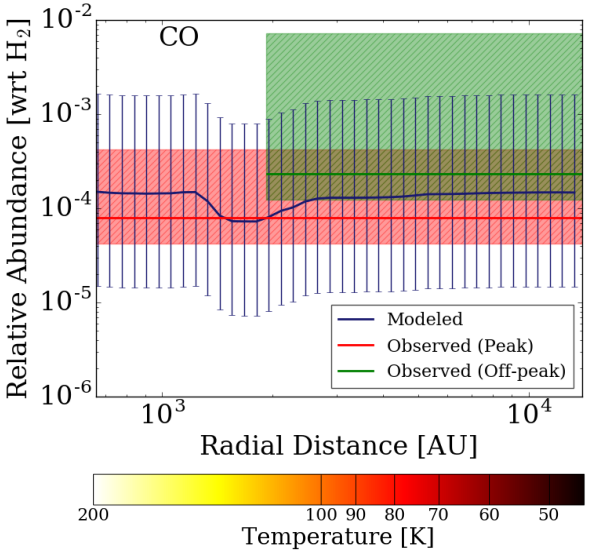

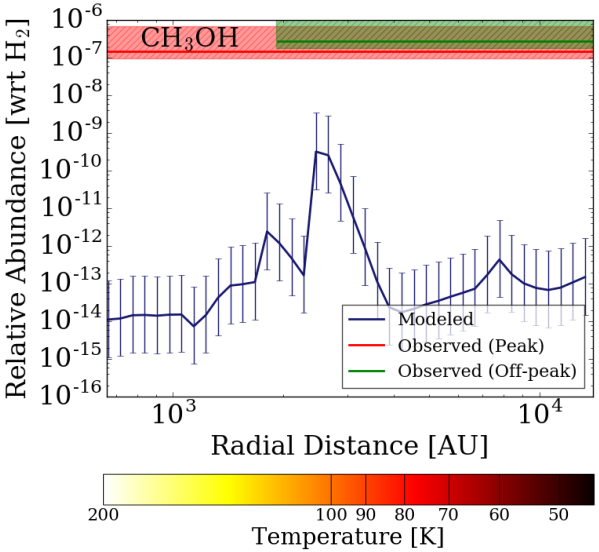

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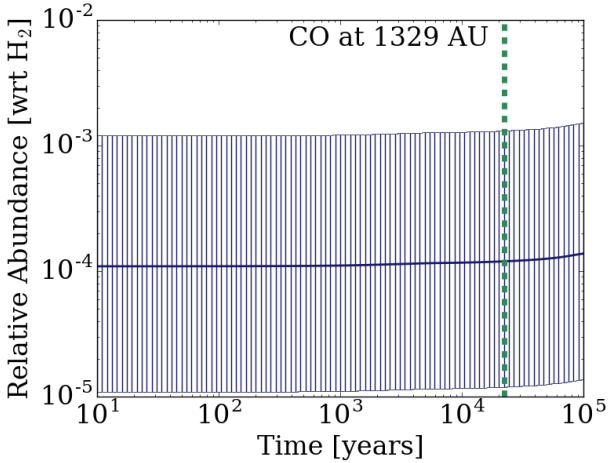

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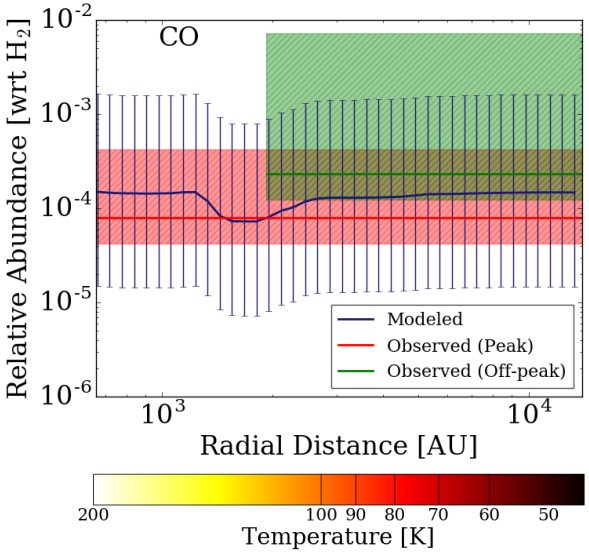

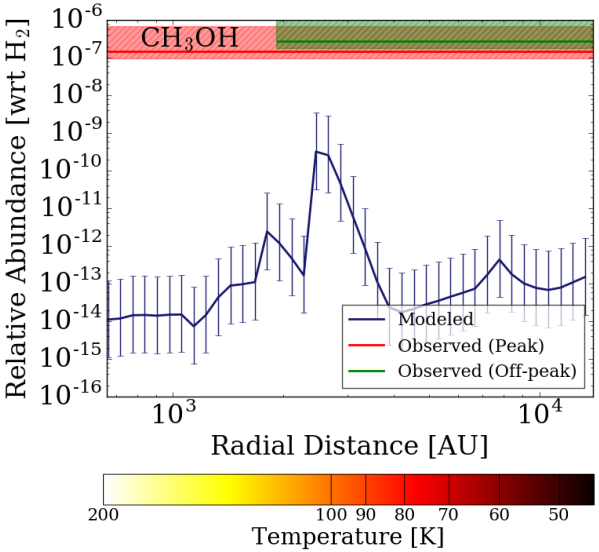

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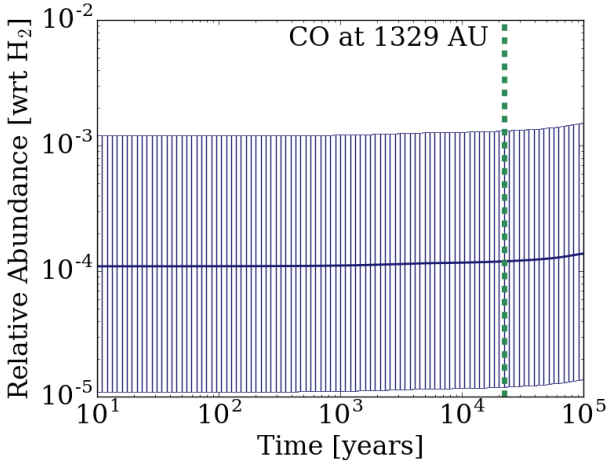

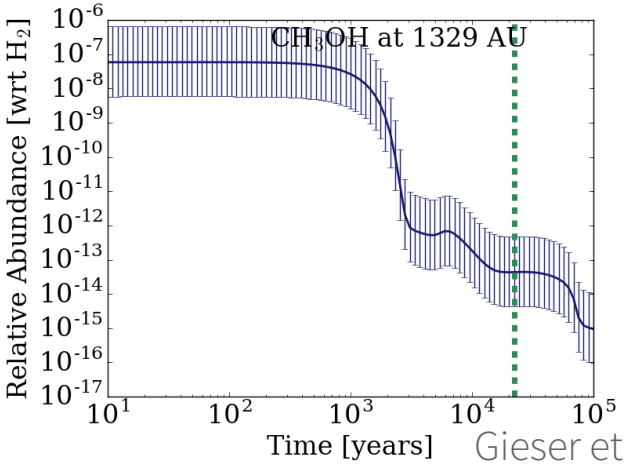

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Conclusions and Outlook

CORE observations:

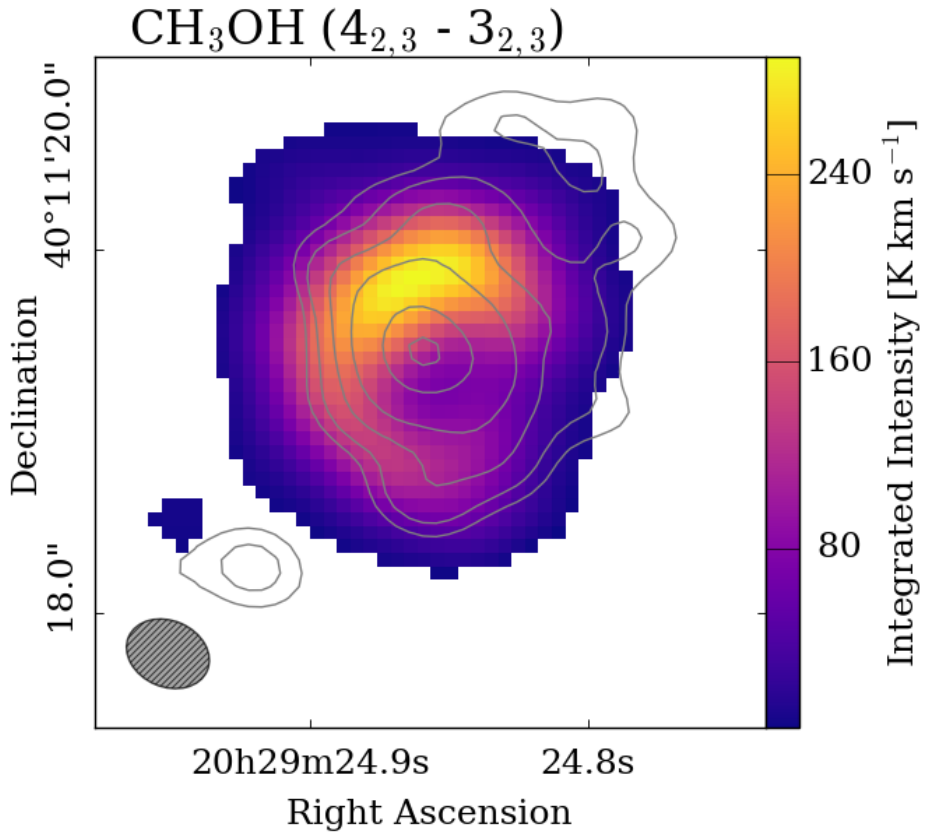
- rich diversity in molecules at 1 mm

  (O-, N-, S-bearing species)

- column density and temperature determination using XCLASS
- chemical segregation

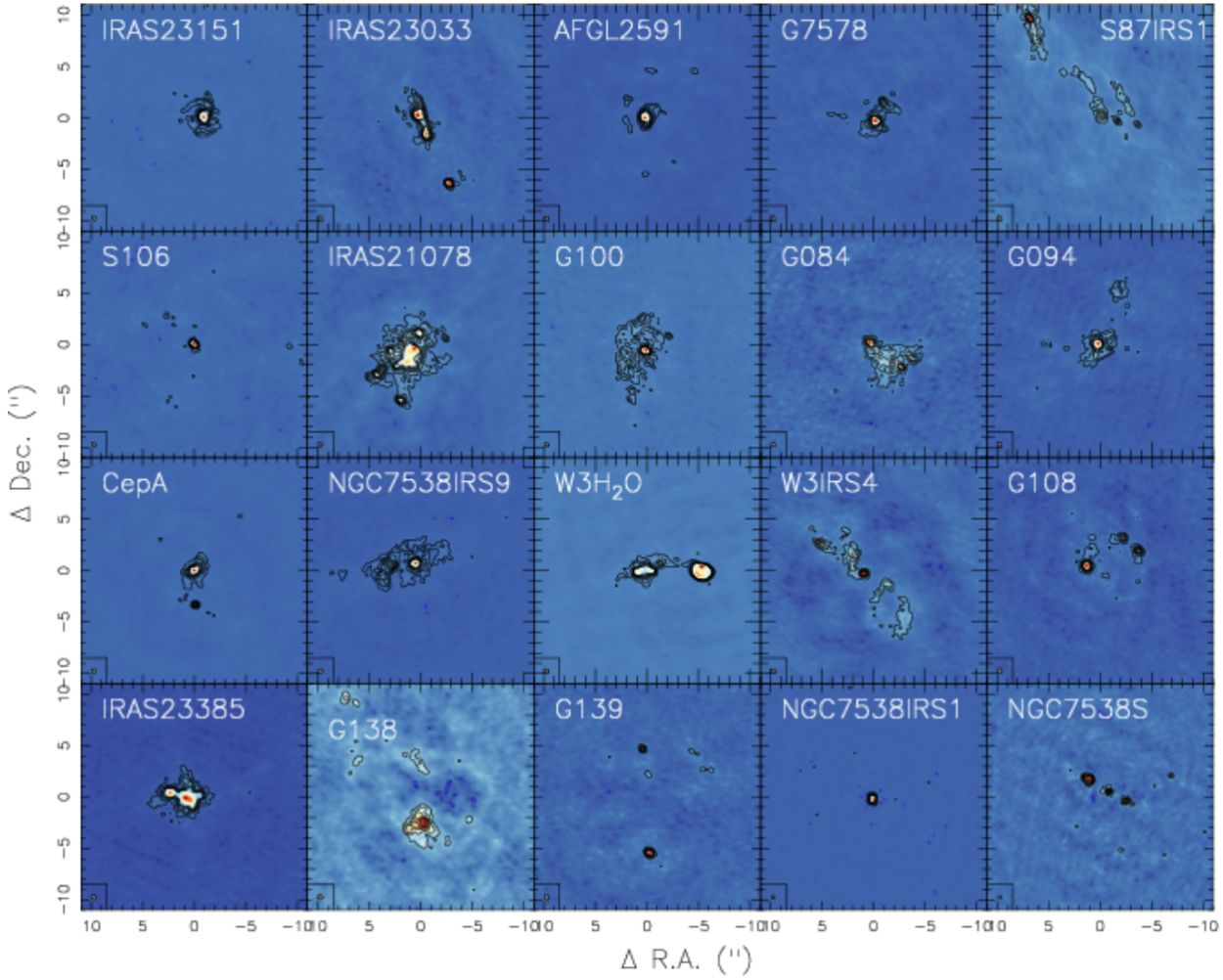
Chemical model using MUSCLE:

- 11 / 16 molecules
- density power-law index: p = 1.1
- chemical age: ≈ 33 000 years
- improvements: dynamic physical structure, 1D → 2D including the outflow



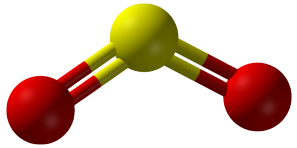
Gieser et al. (in prep.)

Conclusions and Outlook



Beuther et al. (2018)

Chemical Complexity of AFGL 2591



Thank you for your attention!