



# $\text{H}_3^+$ in Dense and Diffuse Clouds

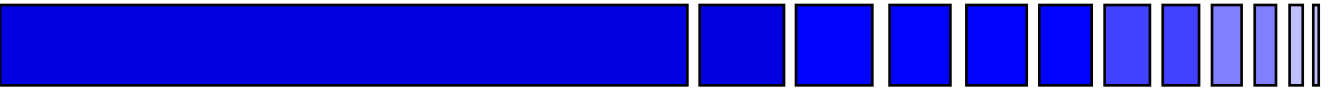
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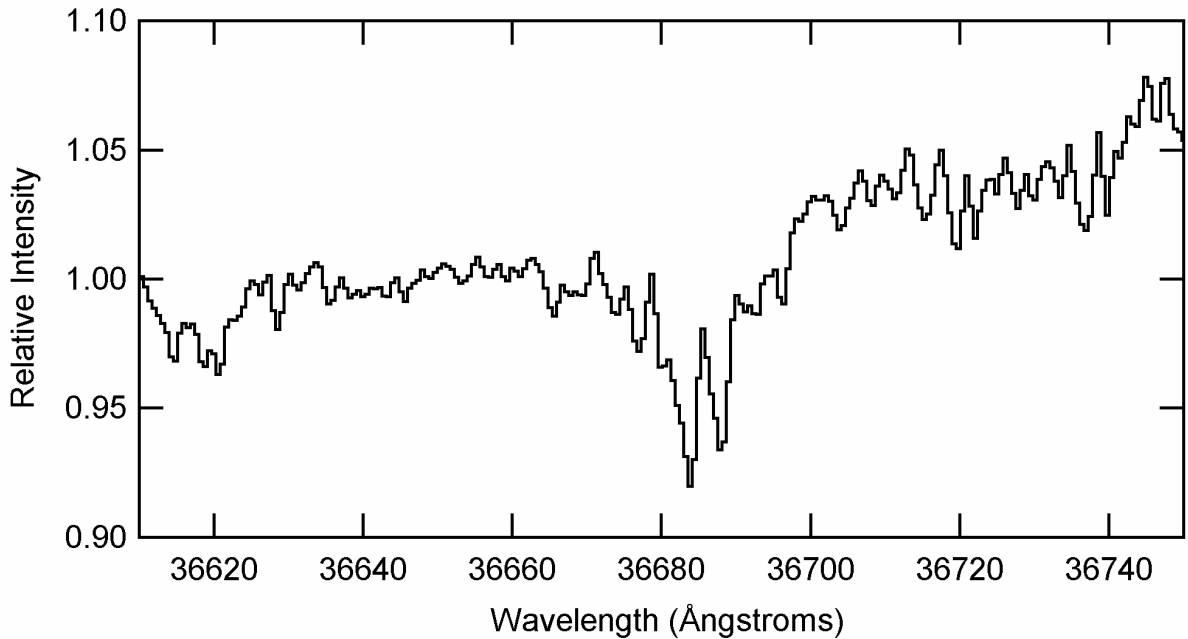
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University of Chicago

# H<sub>3</sub><sup>+</sup> towards the Galactic Center



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GC IRS 3

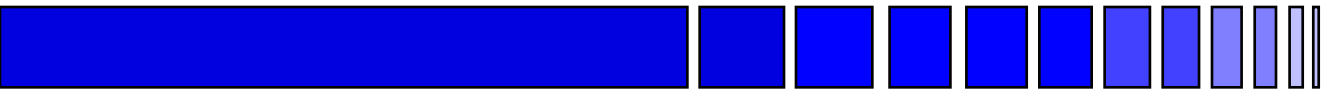
July 11, 1997

UKIRT/CGS4

$$N_{\text{sharp}} \sim 8 \times 10^{14} \text{ cm}^{-2}$$

$$N_{\text{broad}} \sim 16 \times 10^{14} \text{ cm}^{-2}$$

# Summary of H<sub>3</sub><sup>+</sup> Observations



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<u>Object</u>	<u>N</u> (10 <sup>14</sup> cm <sup>-2</sup> )	<u>T</u> (K)
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## Dense Clouds

GL2136	3.6 ± 0.6	35 ± 4
W33A	5.5 ± 1.9	30 ± 6
MonR2/3	2.1 ± 0.7	24 ± 4
GL961E	1.7 ± 0.7	24 ± 5
GL2591	2.0 ± 1.0	~30

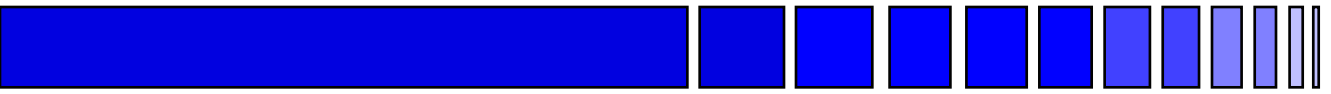
## Diffuse Clouds

OB2#12	3.8 ± 0.5	20 ± 4
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## Galactic Center

GC IRS 3	~24	
GCS 3-2	~19	

# H<sub>3</sub><sup>+</sup> in Dense Clouds



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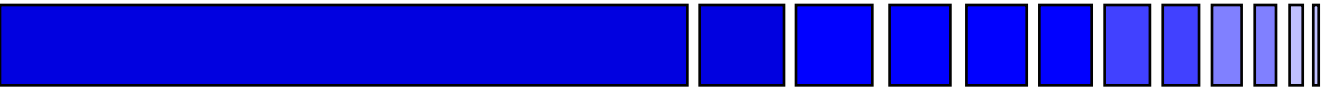
$$\text{Formation Rate} = \zeta [\text{H}_2]$$

$$\text{Destruction Rate} = k_{\text{CO}} [\text{CO}][\text{H}_3^+]$$

$$\text{Steady State} \rightarrow \zeta [\text{H}_2] = k_{\text{CO}} [\text{CO}][\text{H}_3^+]$$

$$\begin{aligned} [\text{H}_3^+] &= \frac{\zeta [\text{H}_2]}{k_{\text{CO}} [\text{CO}]} \\ &\sim \frac{(3 \times 10^{-17} \text{ s}^{-1})}{(2 \times 10^{-9} \text{ cm}^3 \text{ s}^{-1})} \cdot 10^4 \sim 10^{-4} \text{ cm}^{-3} \end{aligned}$$

# H<sub>3</sub><sup>+</sup> in Diffuse Clouds



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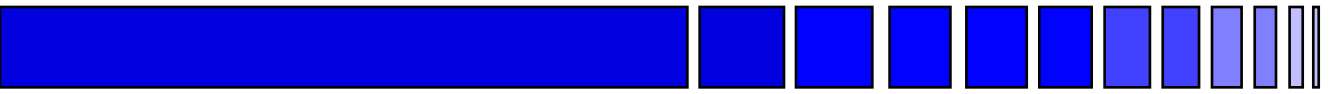
$$\text{Formation Rate} = \zeta [\text{H}_2]$$

$$\text{Destruction Rate} = k_e [\text{e}^-][\text{H}_3^+]$$

$$\text{Steady State} \rightarrow \zeta [\text{H}_2] = k_e [\text{e}^-][\text{H}_3^+]$$

$$\begin{aligned} [\text{H}_3^+] &= \frac{\zeta [\text{H}_2]}{k_e [\text{e}^-]} \approx \frac{\zeta \frac{1}{4}[\text{H}]}{k_e [\text{C}]} \\ &\sim \frac{(3 \times 10^{-17} \text{ s}^{-1}) \cdot \frac{1}{4} \cdot 10^4}{(2 \times 10^{-7} \text{ cm}^3 \text{ s}^{-1})} \sim 10^{-6} \text{ cm}^{-3} \end{aligned}$$

# What is **urgently** needed:



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## ★ $\text{H}_3^+$ Recombination Rate

- ★ experimental values vary from  
 $\sim 2 \times 10^{-8}$  to  $2 \times 10^{-7} \text{ cm}^3 \text{ s}^{-1}$
- ★ interstellar value may be lower

## ★ Cosmic Ray Ionization Rate

- ★ values in the literature vary from  
 $\sim 5 \times 10^{-18}$  to  $5 \times 10^{-17} \text{ s}^{-1}$

## ★ $\text{H}_3^+ + \text{O}$ Rate Coefficient

- ★ only one measurement in 1976
- ★  $\pm 50\%$  error
- ★ not measured at low temperature

## ★ $\text{H}_3^+ + \text{CO}$ Rate Coefficient

- ★ not measured at low temperature