HCN in GV Tau

Emily Sudholt
Advisor Dr. Erika Gibb
What makes Earth so special?

http://www.nature.com/nature/journal/v473/n7348/images/473460a-f1.2.jpg

Big Picture

- What makes Earth so special?
- Where do the necessary ingredients come from? – C, H, O, N
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• What happened during the formation of the solar system?
Big Picture

• What makes Earth so special?
• Where do the necessary ingredients come from? – C, H, O, N
• What happened during the formation of the solar system?
  – physical mixing and changes in chemistry over time
Keck II 10-meter telescope
Mauna Kea, HI

NIRSPEC Near Infrared Echelle Spectrograph

February 17 - 18, 2010
This Research

- GV Tau resembles early stages of this solar system.
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This Research

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• Looking for water, HCN and other simple organics.
This Research

• GV Tau resembles early stages of this solar system.
• Looking for water, HCN and other simple organics.
• Big changes over short time scales.
Method
Method
<table>
<thead>
<tr>
<th>Wavelength (µm)</th>
<th>3.016</th>
<th>3.012</th>
<th>3.007</th>
<th>3.003</th>
<th>2.998</th>
<th>2.994</th>
<th>2.989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flux Density</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Method**

![Graph showing wavelength and flux density relationship](image)
Method
Method

Measured Spectrum
Solar atmospheric model
Method

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Wavelength (µm) 3.016 3.012 3.007 3.003 2.998 2.994 2.989

Flux Density

Measured Spectrum
Solar atmospheric model
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Wavelength 3.016 3.012 3.007 3.003 2.998 2.994 2.989
µm

Flux Density

Frequency cm\(^{-1}\)

Measured Spectrum
Solar atmospheric model
Method

- Boltzmann Distribution

\[ \frac{N_i}{N} = \frac{g_i \exp(-E_i/kT)}{\sum g_i \exp(-E_i/kT)} \]
Method

• Boltzmann Distribution

\[ \frac{N_i}{N} = \frac{g_i \exp\left(-\frac{E_i}{kT}\right)}{\sum g_i \exp\left(-\frac{E_i}{kT}\right)} \]

• Algebra

\[ \ln\left(\frac{N}{(2J''+1)}\right) = (1/T)E \]
Method

• Boltzmann Distribution

\[
\frac{N_i}{N} = \frac{g_i \exp(-E_i/kT)}{\sum g_i \exp(-E_i/kT)}
\]

• Algebra

\[
\ln\left(\frac{N}{(2J''+1)}\right) = \frac{1}{T}E_y
\]
Method

- Boltzmann Distribution
  \[ \frac{N_i}{N} = \frac{g_i \exp(-E_i/kT)}{\sum g_i \exp(-E_i/kT)} \]
- Algebra
  \[ \ln\left(\frac{N}{(2J^"+1)}\right) = \left(\frac{1}{T}\right)E_{yx} \]
Method

- **Boltzmann Distribution**
  \[
  \frac{N_i}{N} = g_i \exp\left(-\frac{E_i}{kT}\right) / \sum g_i \exp\left(-\frac{E_i}{kT}\right)
  \]

- **Algebra**
  \[
  \ln\left(\frac{N}{(2J^"+1)}\right) = \left(\frac{1}{T}\right)E
  \]
  \[
  y = m \times x + b
  \]
  \[
  m^{-1} = T
  \]
Results (preliminary)

- \( \frac{1}{0.00130} = 764K \)

\[ y = -0.0013083x + 33.9673942 \]
Results (preliminary)

- $\frac{1}{0.00130} = 764K \quad T \sim 460K$
Results

• $T \sim 460K$
• Doppler shift: $55 \pm 3 \text{ km/s}$
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• $T \sim 460\text{K}$
• Doppler shift: $55\pm3\ \text{km/s}$

Still need to...

• Subtract HCN
• Identify other organics
Discussion

- 2006 $T = (100-200K)$ Gibb et al. 2006
- 2010 $T \sim 760K$
Discussion

- 2006 $T=(100-200K)$ Gibb et al. 2006
- 2010 $T \sim 760K$
- More material overall
Questions

• Is the change in T due to the larger sample?
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  – Lines $\sim 3200\text{cm}^{-1}$ would not be excited at 200K.
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  - Lines ~ 3200 cm$^{-1}$ would not be excited at 200K
- Is this the same region of the disk?
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• Is the change in T due to the larger sample?
  – Lines ~ 3200 cm$^{-1}$ would not be excited at 200K

• Is this the same region of the disk?
  – If the disk is warped, we may be looking at a different layer.
Acknowledgements

- NASA Missouri Space Grant Consortium
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