Effects of the X-rays from stellar source and UV from external radiation field on the astrophysical ices survival in protostellar environments

W. R. M. Rocha

S. Pilling
Outline

1.0 Introduction and Motivation
2.0 Case for Elias 29
3.0 Methodology
4.0 Results
  4.1 Disk
  4.2 Envelope (Temperature)
  4.3 Envelope (half-life)
5.0 Where are the ices?
Conclusions
1. Introduction and Motivation


https://www.youtube.com/watch?v=X_jSenHTqFw
2. Case for Elias 29

Class I \((1.4 \times 10^5\) years, Chen et al. 1995)

Luminosity: \(16.5 \, L_\odot\) (Rocha & Pilling 2015)

Distance: 120 \(R_\odot\) (Rocha & Pilling 2015)

Coordinates
\(\alpha\) (J2000) = 16h27m09.3s
\(\delta\) (J2000) = -24°37'21"

Elias 29 spectrum
3. Methodology

Astrophysical scenario

Protoestellar disk

Observed SED

Comparison

Observational part

Laboratory (Absorbance) → Refractive index \(n\) \(e\) \(k\) → Opacities → Radiative transfer → Syntetic SED and image

Experimental part

Computational Part (RADMC-3D – Dullemond et al. in prep)
3. Methodology

• Mean intensity calculated by RADMC-3D:

\[ J_\nu = \frac{1}{4\pi} \int I_\nu(\Omega)d\Omega \]

• Photodissociation rate:

\[ k_{pd} = \int_{\nu_i}^{\nu_H} 4\pi \mathcal{N}_{ISRF}(\nu) \alpha_{pd}(\nu) d\nu. \]

• Half-life:

\[ t_{1/2} = \frac{\ln(2)}{k} \]
3. Methodology

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Employed Value (see text)</th>
<th>Estimated Range</th>
<th>Literature Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_d\ (M_{\odot})$</td>
<td>Disk mass</td>
<td>0.003</td>
<td>0.002–0.007</td>
<td>$&lt;0.007^{b}$</td>
</tr>
<tr>
<td>$R_{d,\text{in}}\ (\text{AU})$</td>
<td>Disk inner radius</td>
<td>0.36</td>
<td>fixed</td>
<td>0.25$^{f}$</td>
</tr>
<tr>
<td>$R_{d,\text{out}}\ (\text{AU})$</td>
<td>Disk outer radius</td>
<td>200</td>
<td>fixed</td>
<td>200$^{e}$</td>
</tr>
<tr>
<td>$M_{\text{env}}\ (M_{\odot})$</td>
<td>Envelope mass</td>
<td>0.028</td>
<td>0.02–0.06</td>
<td>$&lt;0.058^{e}$</td>
</tr>
<tr>
<td>$R_{\text{env,in}}\ (\text{AU})$</td>
<td>Envelope inner radius</td>
<td>0.36</td>
<td>fixed</td>
<td>...</td>
</tr>
<tr>
<td>$R_{\text{env,out}}\ (\text{AU})$</td>
<td>Envelope outer radius</td>
<td>6000</td>
<td>fixed</td>
<td>6000$^{g}$</td>
</tr>
<tr>
<td>$\theta_{c}\ (\cdot)$</td>
<td>Cavity angle</td>
<td>30</td>
<td>25–55</td>
<td>40$^{h}$</td>
</tr>
<tr>
<td>$d\ (\text{pc})$</td>
<td>Distance</td>
<td>120</td>
<td>100–160</td>
<td>125$^{i}$, 160$^{g}$</td>
</tr>
</tbody>
</table>

**Notes.**

a McClure et al. (2010).
b Miotello et al. (2014).
c Evans et al. (2003).
d Chen et al. (1995).
e Lommen et al. (2008).
f Simon et al. (1987).
g Boogert et al. (2002a).
h Beckford et al. (2008).
i de Geus et al. (1989).

3. Methodology

Stellar SED for a typical protostar (Siebenmorgen & Krügel 2010)
4.1 Results - Disk

Internal and External UV

Internal UV and X-ray + External UV

4.2 Results – Environment (temperature)

4.3 Results – Envelope (half-life)

[Graph showing the relationship between R (AU) and Z (AU) with different values for 30 cm$^3$, 140 cm$^3$, 900 cm$^3$, 4 x 10$^{-2}$, 1.7 x 10$^{-2}$, and 7.5 x 10$^{-3}$, with half-life times ranging from 7.29 x 10$^{-11}$ to 2.24 x 10$^{6}$ years.]

04/july/2016  International Symposium and Workshop on Astrochemistry
5. Where are the ices?
5. Where are the ices?

ICES ARE PLACED AT THE FOREGROUND CLOUD???
Conclusions

• External radiation field can heats the envelope, and dessorbs volatiles molecules like CO;
• Water-rich ices can survive inside the disk, when UV radiation field is considered;
• On the other hand, if X-ray are assumed, water-rich ices are thoroughly photodissociated;
• Toward Elias 29, ices takes place at the foreground cloud.
Enjoy the meeting!!!