ABSTRACT
We present preliminary models of the infrared emission from gas in young disks with optically thick dust. We focus on the separate calculations of the gas and dust temperatures near the disk surface, where gas and dust decouple and their temperatures differ. We use a modified Chiang and Goldreich (1997) dust disk model to numerically determine the dust temperature. The gas temperature near the surface is determined by a thermal balance calculation, which includes a self-consistent computation of the gas density and temperature in the disk. The model includes line emission from disk dust and gas emission lines. Our preliminary disk model is for a passive disk, with no heating due to viscous accretion, orbiting a 1 Myr old solar-type star. We present dust continuum and gas emission lines. Our preliminary disk model is for a passive disk, with no heating due to viscous accretion, orbiting a 1 Myr old solar-type star. We present the thermal structure, chemistry, main heating and cooling processes in the disk, resulting emission lines and mass loss rate by photoevaporation caused by the stellar radiation field.

MODEL DESCRIPTION
- Photolysis model (Chiang & Goldreich, 1997) dust disk model
- Stellar radiation field that includes UV and X rays typical of young stars
- Vertical density structure and chemistry calculated self-consistently by imposing thermal balance, amphoteric chemistry and pressure equilibrium
- Models assume geometrically thin disk, no accretion or viscous heating
- Dust and gas are assumed well mixed, i.e., there is no settling
- Heating due to X-rays, stellar and interstellar UV fields, exothermic chemical reactions and other mechanisms. Cooling due to atoms and molecules, collisions with dust
- Dust and gas are assumed geometrically thin disk, no accretion or viscous heating

MODEL PARAMETERS
- Stellar Radiation: Kurucz model
- Dust composition: Standard silicate
- Disk mass: $M_{\text{disk}} = 0.01 M_\odot$
- Surface density distribution: $\Sigma(r) \propto r^{1.5}$
- X-ray energy: $0.5-10$ keV; $L_X \sim 10^{35}$ erg/s
- UV energy: $L_{\text{UV}} \sim 10^{30}$ erg/s
- Disk size: $0.35 \text{AU} < r < 80 \text{AU}$
- Disk grain size: $50 \text{Å} < a < 20 \text{m}$
- Dust composition: Astronomical silicate
- Disk thickness: $d = 1 \text{AU}$
- Chemical reactions

OPTICALLY THICK DISK MODEL: RESULTS

Gas and dust temperatures as a function of height (AU). The vertical lines mark the regions where the line emission from the indicated species originate.

Gas Emission Lines

<table>
<thead>
<tr>
<th>Line</th>
<th>Wavelength</th>
<th>Line Intensity</th>
<th>Linewidth</th>
<th>Ratio</th>
<th>Flux at 100pc</th>
</tr>
</thead>
<tbody>
<tr>
<td>[O I]</td>
<td>63 um</td>
<td>2.1 x 10^12</td>
<td>2.1 um</td>
<td>43%</td>
<td>5.0 x 10^14</td>
</tr>
<tr>
<td>[Si II]</td>
<td>158 um</td>
<td>9.0 x 10^14</td>
<td>9.0 um</td>
<td>68%</td>
<td>1.5 x 10^14</td>
</tr>
<tr>
<td>CO 1-0</td>
<td>2.1 um</td>
<td>1.0 x 10^12</td>
<td>1.0 um</td>
<td>68%</td>
<td>1.0 x 10^14</td>
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</tr>
</tbody>
</table>

Summary
- Main heating mechanisms are Grain Photothermic heating, X-rays and photodissociation and photodissociation reactions
- Gas emission arises from the "superheated" surface where gas is typically hotter than the dust.
- X-rays from the central star dominate the heating, with UV and optical radiation being weaker.
- The heating from [SiII] emissions is above the photodissociation limit, suggesting some level of dust sublimation.
- Temperatures above the photospheric level are due to the combined action of exothermic chemical reactions and the X-ray heating.
- The dust temperature is lower than the gas temperature in the disk midplane but higher near the disk surface, where gas and dust decouple.

PHOTOEVAPORATION

Results
- Photoevaporation of disk due to the radiation field of the central star can be significant.
- Mass loss rate increases with radius and the disk surface temperature.
- Disk beyond 20 AU with mass 0.01 M$_\odot$ is photoevaporated on timescales ~ 10 Myr.

References