Why cloud are completely opaque? 
and not just an absorption lines? 

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Optical depth \( \tau_\lambda = \int N_\lambda \text{d}Z \)
where \( \tau_\lambda \) is the optical depth, \( N_\lambda \) is the column density, \( \lambda \) is the wavelength, and \( Z \) is the distance.

\[
\tau_\lambda \propto \frac{a^3}{\lambda}, \quad \lambda \gg a
\]
so bluish light absorbed stronger and transmitted appears redder.

Scattered though is bluish

\[
\text{transmit} \quad I_\lambda \propto \lambda
\]

Sky is blue, sunset/sunrise is red
Cloud Composition - Interstellar Medium (ISM)

H - hard to detect but there is forbidden transition due to splitting of ground level (spin interaction)

at $\lambda = 21$ cm $\leftrightarrow f \approx 1.4$ GHz

H$_2$ - molecular hydrogen only at high temperature > 2000K when vibration bands are excited

PAH - polycyclic aromatic hydrocarbons complex molecular resonance lines

Dust - big size clumps

$\sigma_\lambda = \frac{a^2}{\lambda}$

Spectrum is more red which hints on composition need to be taken into account or thus give information on cloud composition

Light after cloud is polarized $\Rightarrow$ need B field to orient molecular or dust
Emission nebula

Emission of recombination of H ions (H II) created by U.V. radiation of nearby stars

U.V. photon absorbed (λ < 91.2 nm)

when it recombines back it emit a lower energy (higher λ) photons

these are not absorbed since if require an electron on a higher exited level

so we see these photons in visible. (Balmer lines give redish tint)

H cloud
Size of emission nebula

we see emission only till propagating light has U.V. photons

\[ N_{0(\text{UV})} \quad \text{H}_\alpha \]

\[ \text{photons} \]

\[ \text{H}_\text{II} \quad \text{H}_\text{III} \]

\[ \text{# of photons} \]

but then ion (\text{H}_\text{III}) recombines and is available for U.V. absorption

so recombination \[ = \text{photons in U.V.} \]

\[ (2 \cdot \text{ne} \cdot N_{\text{H}_\text{III}}) \cdot V = \text{photons} = \frac{L}{h \cdot \text{ionization}} \]

\[ \text{m}^3/\text{s} \] recombination coef, \[ L \approx 3 \cdot 10^{19} \text{ m}^3/\text{s} \] for \( T=8000 \)

Note \( (2 \cdot \text{ne} \cdot N_{\text{H}_\text{III}}) \cdot V \) is recombination rate \[ \frac{\text{#/s}}{\text{unit}} \]

\[ \frac{L \cdot \text{ne} \cdot N_{\text{H}_\text{III}}}{3} \cdot \frac{4}{3} R_s^3 = N \]

\[ \frac{2}{n_n} \cdot \frac{1}{n_n} \]

Size of emission nebula

\[ R_s = \left( \frac{3}{4 \pi} \cdot N \right)^{1/3} \cdot \frac{1}{N_{\text{H}}} \]

Strömgren radius

(typically \( R_s = 0.1 \div 100 \text{pc} \), \( N_{\text{H}} \approx 10^{8} \text{ m}^{-3} \))
Why there are no super heavy star, but a bunch of smaller one

Angular momentum issue

So far we assumed that matter fell straight to center of the cloud.

But if it rotates just a bit than we have to worry about speed up of rotation.

\[ \text{faster rotation} \]

Initial angular momentum of outside region

\[ m_0 \Omega_0 = m_0 \Omega_f \]

If \( r_0 = 3 \times 10^{15} \text{ km} \)

\( \Omega_0 = 4 \times 10^8 \)

\( v_0 = 1 \text{ km/s} \)

\[ \Omega_f = \frac{v_0}{r_f} = 10^8, \quad \frac{3 \times 10^{15}}{4 \times 10^8} \approx 4 \times 10^{10} \text{ m/s} \]

Faster than speed of light!

So only part of cloud could compress to should be small multistar system

or angular momentum should be ends here
Another option = angular momentum should be "dropped" away

\[ \Rightarrow Jets \]

\[ \begin{align*}
\text{accretion disk} & \quad \Rightarrow P_t = P_i + P_e \\
\text{P disk formation} & 
\end{align*} \]

Another way to see it:

accretion disk

This part cannot go to close to star

but polar can

forbidden for in plane