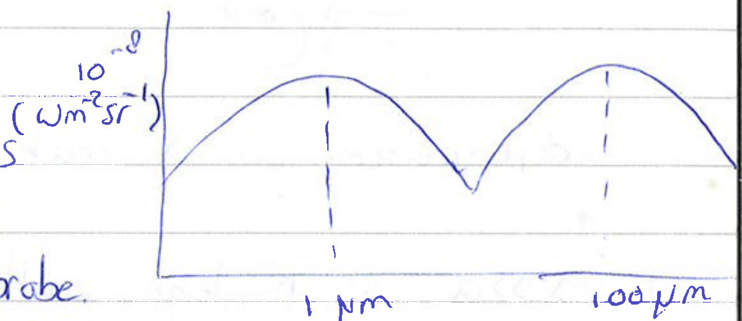
Interstellar Medium 11-11-2019

Interstellar dust

Dust emits in infrared. Dust is not a black body radiator. Emission spectrum has features around 10 μm. ULIRGS are completely dominated by infrared emission. When integrating all backgrounds, except for CMB, the infrared emission is about ~~at~~ as strong as starlight



As 50 % of light comes out in the infrared, this must be an important probe.

Light is reflected by dust, not by molecules or atoms. Extinction has wavelenght dependence : red light is absorbed less than blue, causing reddening.

Dust grains are not molecules ; we are in the macroscopic limit. We thus need to talk about electro-magnetic (light) interaction. EM wave interacting with body depends on dielectric function of the body.

$$\varepsilon(\omega) = \text{depends on material}$$

$\hookrightarrow$ ~~2πf~~ $2\pi\nu$

- Conducters : $\varepsilon = 0$

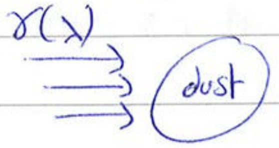
-

Dust not conductor ; need to know material, shape, size will assume spherical grains with radius a

ee regimes

1. $\lambda \ll a$
2. $\lambda \gg a$
3. $\lambda \approx a$

$\lambda \ll a$: dust grain basically big obscuring screen $\Rightarrow$ geometric optics



-dependence on λ weak.

$\lambda \gg a$: Rayleigh scattering (makes the sky blue)

$$\tau(\lambda) = \int \kappa_D(\lambda)\, dl$$

$\kappa_D \leftarrow$ dust absorption coefficient.

Dust has cross section for ~~absorption~~ extinction

$$\kappa_D = n_d^{(a)}\, C_{ext}^{(a)}(\lambda)$$

↑ dust grain density

tinction cross section $C_{ext} = C_{abs} + C_{scatter}$

sth remove light from the beam.

$$C_{abs} \propto \frac{1}{\lambda^2}, \quad C_{scat} \propto \frac{1}{\lambda^4}$$

These λ- relations are true for every material. Thus for large λ, absorption dominates, thus in that case $C_{ext} \propto \lambda^{-2}$. Has nothing to do with material, only with grain size.

Smallest dust grains must be a lot smaller than 1000 Å, as we see from extinction curves. We must also have large grains of > 100 μm. There are 'spectral features' in extinction curve. Most prominent is 2175 Å

aromatic carbon, which has benzeen ring.

Furthermore @ 10 and 18 Å some silicates. These spectral features are somewhat dominated. There are many extinction curves, having different R_V.

$$R_V = \frac{A_V}{A_B - A_V} = \frac{A_V}{E(B-V)} = \frac{\text{extinction}}{\text{reddening}}.$$

Typically, $R_V = 3.1$ for milky way.

Composition of dust

→ made from heavy elements ($M_{>He} \approx 1\% \; M_H$)

By mass, most of heavy elements, are embedded in dust. Indeed $M_{grain} / M_H \approx 0.01$

Grains of different sizes

→ power law dist. of grain sizes

$a_{min} = 0.005 \; \mu m$, $a_{max} = 0.25 \; mm$

$$\frac{dn_{grain}}{da} = A n_H a^{-3.5}$$

ss dominated by large grains, extinction
inated by small grains.

ns with power law size distr.
- carbonates + silicates

tional ingredients

Very small grains

So small that they can be heated by single photons & will radiate away excess heat in exp way.

Larger grains are at stable temperature because their cross section is much larger and thus cooling time is long.

Very prominant features PAHS.

-> polycyclic, aromatic : little plates of graphite.

Border between molecules and dust grains.

No real em. lines, rather bands related to vibrational modes.

Many possible vibrations possible in plain of molecule

Ices

o far grains were carbonates or silicates How-
ver molecules can freeze on the surface of
ust and form ice : H_2O, CO, CO_2, NH_3 ~~CH_4~~, etc

Grain surfaces are so cold that there is a fair probability for a molecule to stick on the dust. Probably the main process for forming water.

⇒ Dust-chemistry is important process