10/24/2000

Charlie Lada

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Interstellar Dust

1) William Herschel 1738–1822
   Caroline 1750–1848

"ein Loch im Himmel" = hole in the heavens (ex: Ophiuchus) ← catalogue of dark patches → many "holes" near star clusters

30" telescope → sky survey; star counts → map of structure of universe (stars = std. candles)

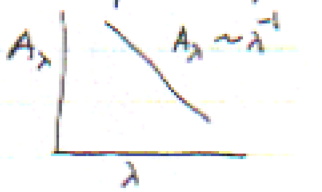
2) E.E. Barnard 1857–1923 ⇒ CLOUDS
   photographs of sky (a photographer)

3) V.M. Slipher (1912) ⇒ Reflection Nebula ⇒ small particles (Rayleigh scatt.)
   spectra of Pleiades → match stellar spectra

4) R. Trumpler (1886–1956) (see below)

$L = \frac{L}{4\pi D^2}$

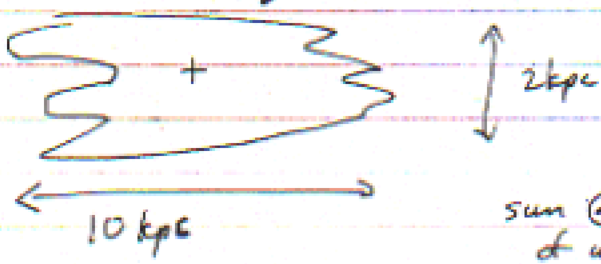
λ-dep of absorption



Absorption / Extinction due to dust
(not covered: polarization, spectra, emission/reradiation)
recommended book: (Whitter (?))

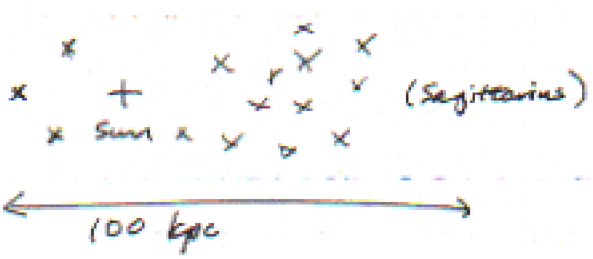
Kapteyn (1851–1922)
star counts:

(map similar to Herschel — added scale)



sun @ center of universe

Harlow Shapley – globular clusters

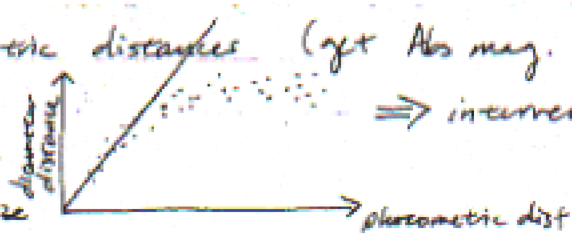


g.c's concentrated near Sag.

(Shapley – Curtis debates)

Trumpler – photometric distances (get Abs mag. fr. spectral type)

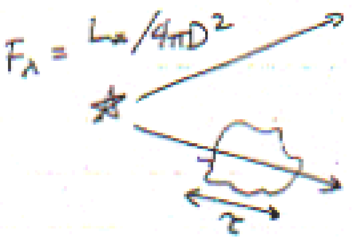
$L = \frac{L}{4\pi D^2}$



assume all glob. clus. same size

⇒ intervening medium absorption 0.7 mag/kpc zone of avoidance – spiral nebulae appear uniformly except for plane of M.W.

why study dust? it just gets in the way!



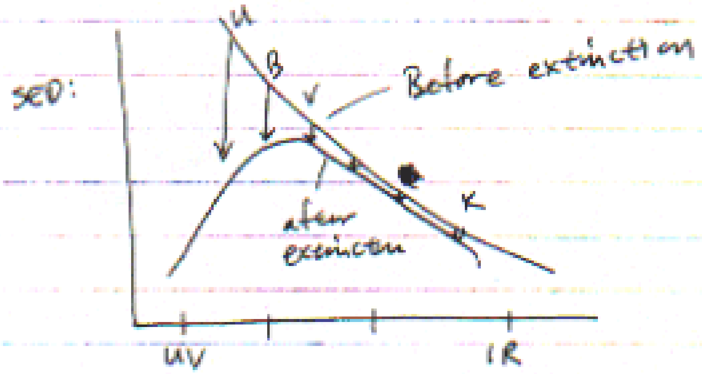
$\triangleright \quad F_\lambda \Rightarrow m_\lambda = -2.5 \log \frac{F_\star}{F_{vega}}$

$\triangleright \quad F_\lambda e^{-\tau} \Rightarrow m'_\lambda = -2.5 \log \frac{F_\star e^{-\tau}}{F_{vega}}$

$= \underbrace{-2.5 \log F_\star}_{m_\lambda} + \underbrace{1.086\, \tau_{dust}}_{A_\lambda}$

$m_{obs} = m_\lambda + A_\lambda$

$$m_v - M_v = 5 \log d - 5 + A_\lambda$$



$$B_\lambda(T) = \frac{2\pi hc^2}{\lambda^5}\left[e^{hc/\lambda kT} - 1\right]^{-1}$$

Wien: $\lambda << \frac{hc}{kT}$

$B(T) \sim e^{-c/\lambda}$

$$A_\lambda \sim \frac{1}{\lambda} \Rightarrow \tau_\lambda \sim \frac{1}{\lambda}$$

$F_{obs} = F_\lambda e^{-1/\lambda} \Rightarrow$ mimics Wien law
↳ Reddening
↳ effectively shifts the BB

extinction more impt @ short wavelengths

Color Excess

$$E(m_{\lambda_1} - m_{\lambda_2}) = \underbrace{(m_{\lambda_1} - m_{\lambda_2})_{obs}}_{\text{essentially a flux ratio} \rightarrow \text{steepness of SED}} - (m_{\lambda_1} - m_{\lambda_2})_{intrinsic}$$

$$= -2.5 \log \left[\frac{(F_{\lambda_1}/F_{\lambda_2})e^{-(\tau_1 - \tau_2)}}{F_{\lambda_1}/F_{\lambda_2}}\right] = 1.086(\tau_{\lambda_1} - \tau_{\lambda_2})$$

$$= A_{\lambda_1} - A_{\lambda_2}$$

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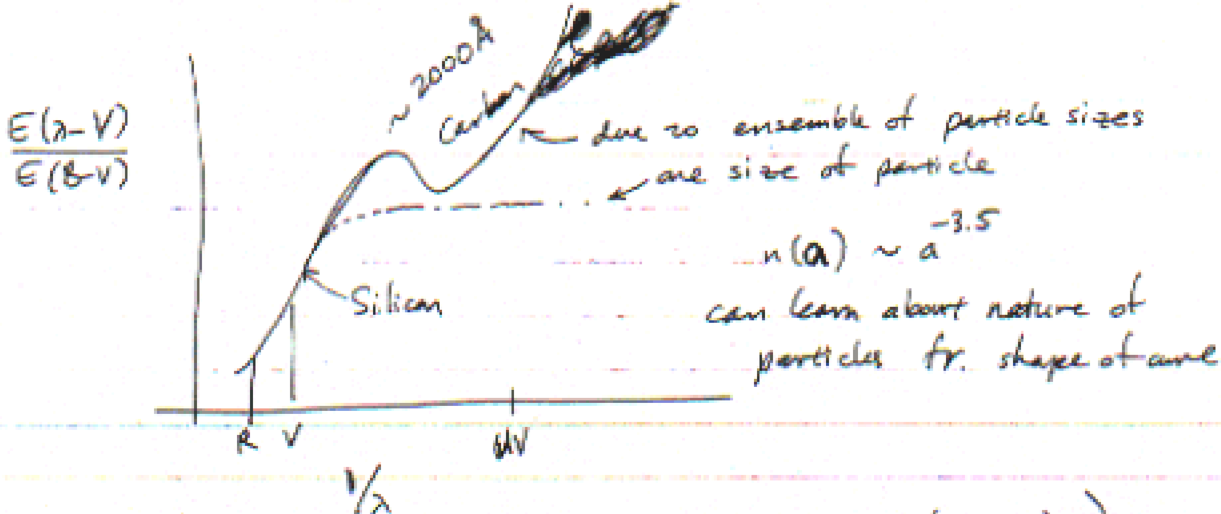

$$\tau_D = N_D\, Q_{ext}(\lambda)\, \pi a^2$$

$$Q_{ext}(\lambda) = Q_{abs}(\lambda) + Q_{scatt}(\lambda)$$

Theory (scattering)