

Interstellar Dust

- Interstellar extinction
- Interstellar reddening
- Dust emission

Interstellar Extinction

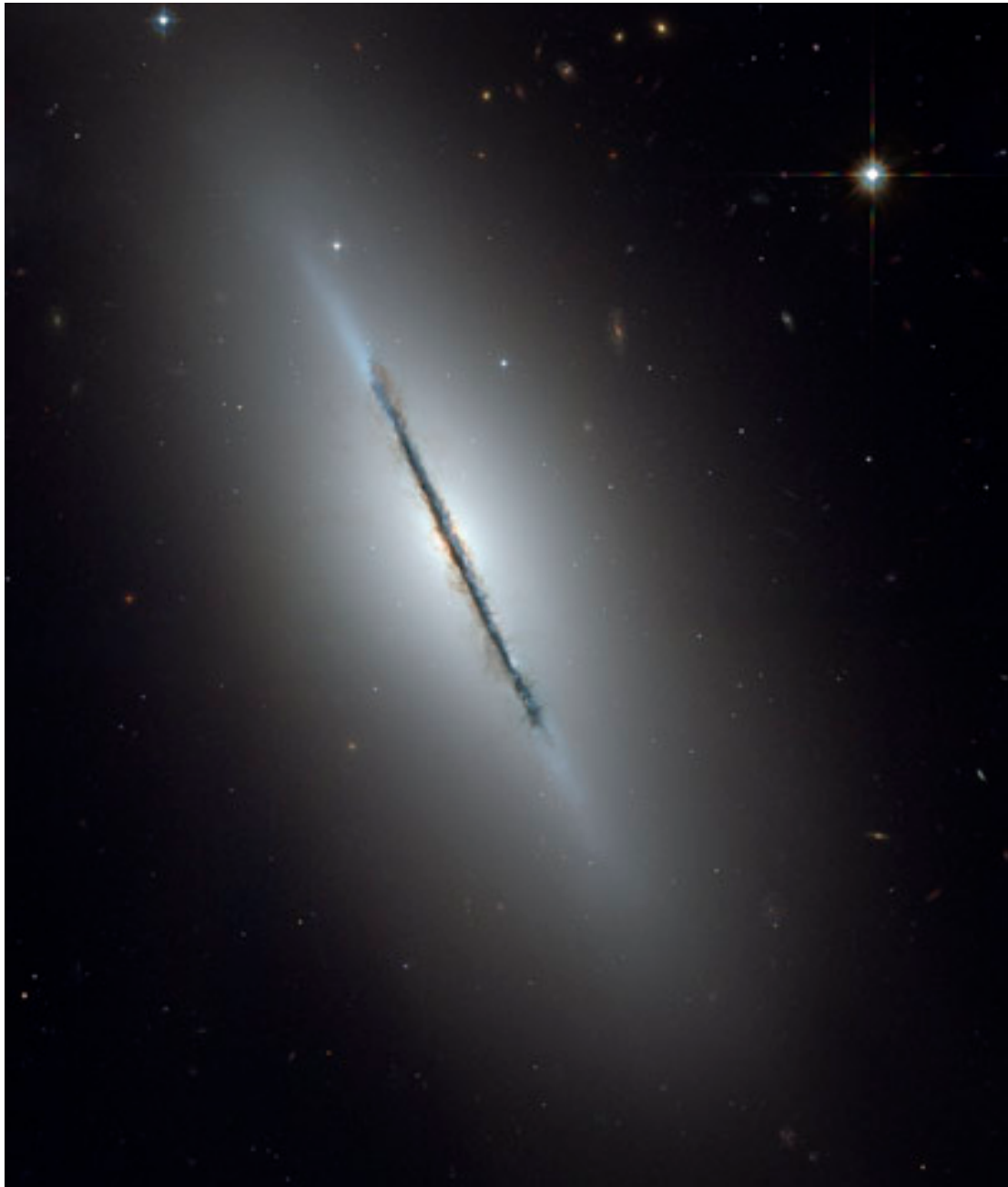
- The presence of interstellar dust is inferred from the dark extinction lanes seen in our Galaxy and other galaxies
- Background starlight or nebular light is blocked out
- The dust is made of small grains mixed with the interstellar gas
- Grain size ~ 5 to 500 nm, i.e. $\sim \lambda$ of light



M64: Credit: NASA and The Hubble Heritage Team (AURA/STScI)



M104: Credit: NASA and The Hubble Heritage Team (AURA/STScI)



NGC5866: Credit: NASA and The Hubble Heritage Team (AURA/STScI)

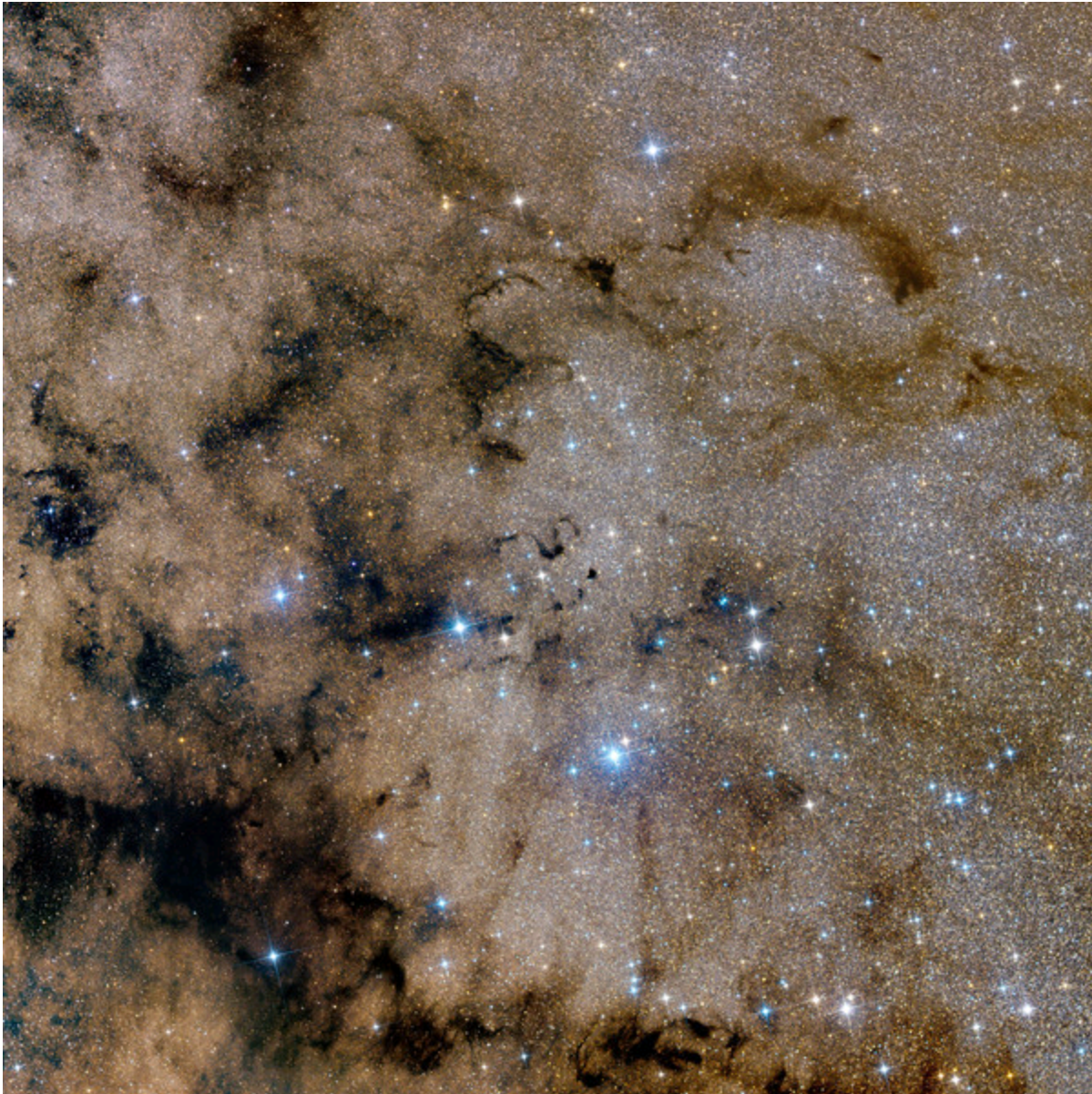
Visual Extinction

- The dust along the line of sight causes objects to appear dimmer
- This amount of dimming is measured in magnitudes and is called total extinction
- In the V-band this is called A_V

$$A_V = m_V(\text{observed}) - m_V(\text{intrinsic})$$

- In terms of absolute magnitude

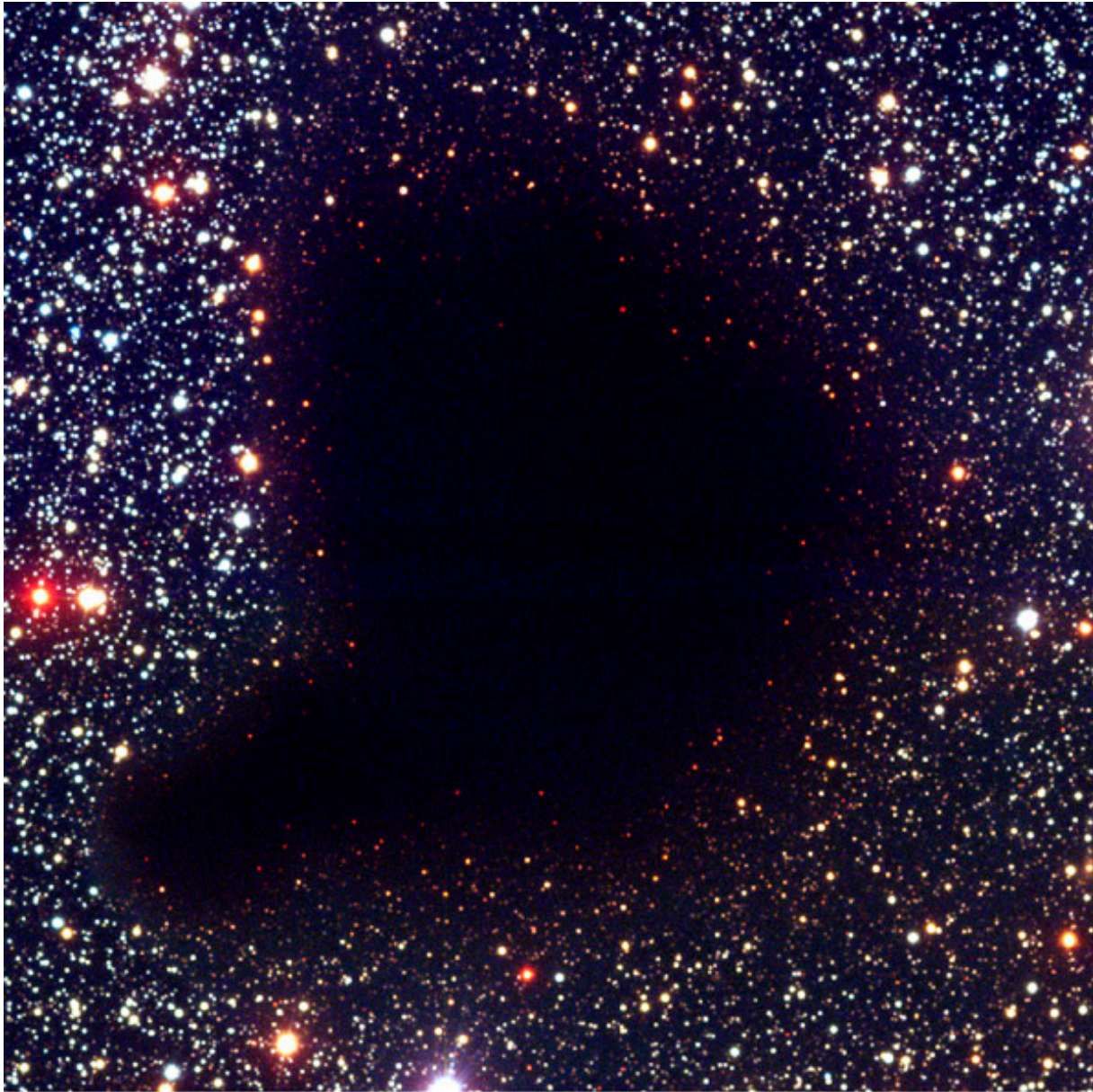
$$m_V - M_V = 5 \log d - 5 + A_V$$



Interstellar dust clouds

Interstellar Reddening

- The amount of extinction varies with wavelength
- Extinction is larger at blue wavelengths than red wavelengths, i.e. $A_B > A_V$
- Therefore interstellar dust causes background objects to appear redder as well as dimmer



B, V, I



Credit: NASA, NOAO, ESA and The Hubble Heritage Team (STScI/AURA)

Colour Excess

- The amount of reddening is also measured in magnitudes and is the difference between the observed and intrinsic colour

$$E(B - V) = (B - V)_{\text{observed}} - (B - V)_{\text{intrinsic}}$$

- This is called the colour excess

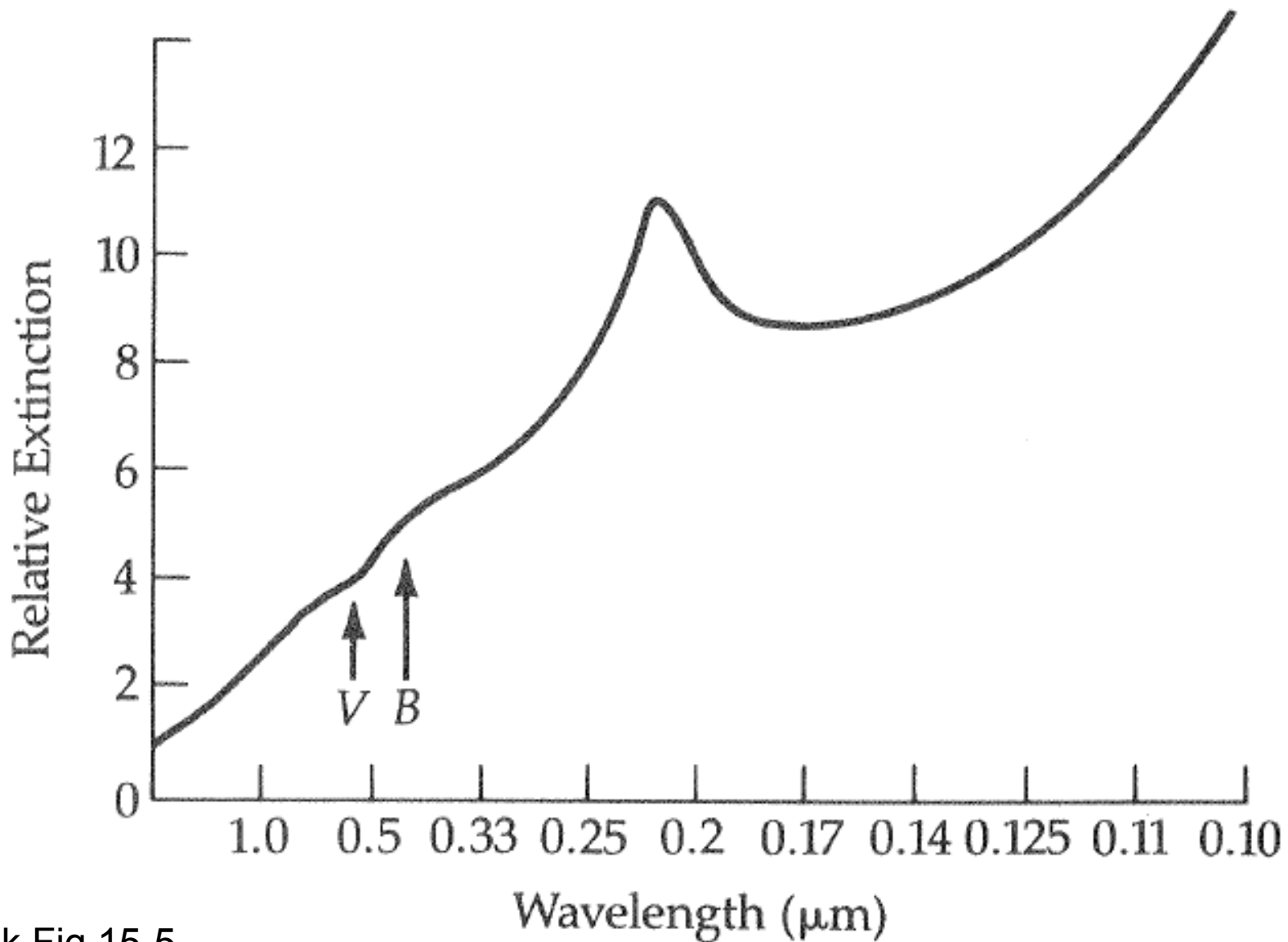
Extinction Law

- How the extinction varies with wavelength is called the extinction law
- The slope of the law allows the visual extinction to be related to the colour excess

$$A_V \approx 3E(B - V)$$

- If the intrinsic colour of a source is known, then the extinction can be measured

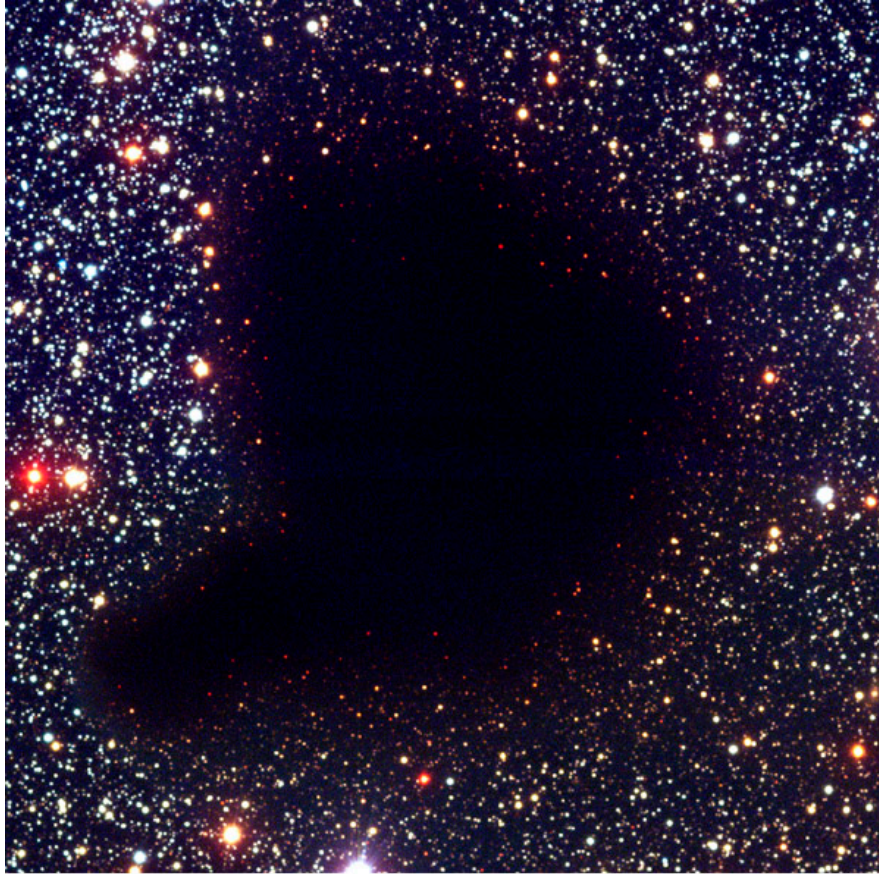
Interstellar extinction law



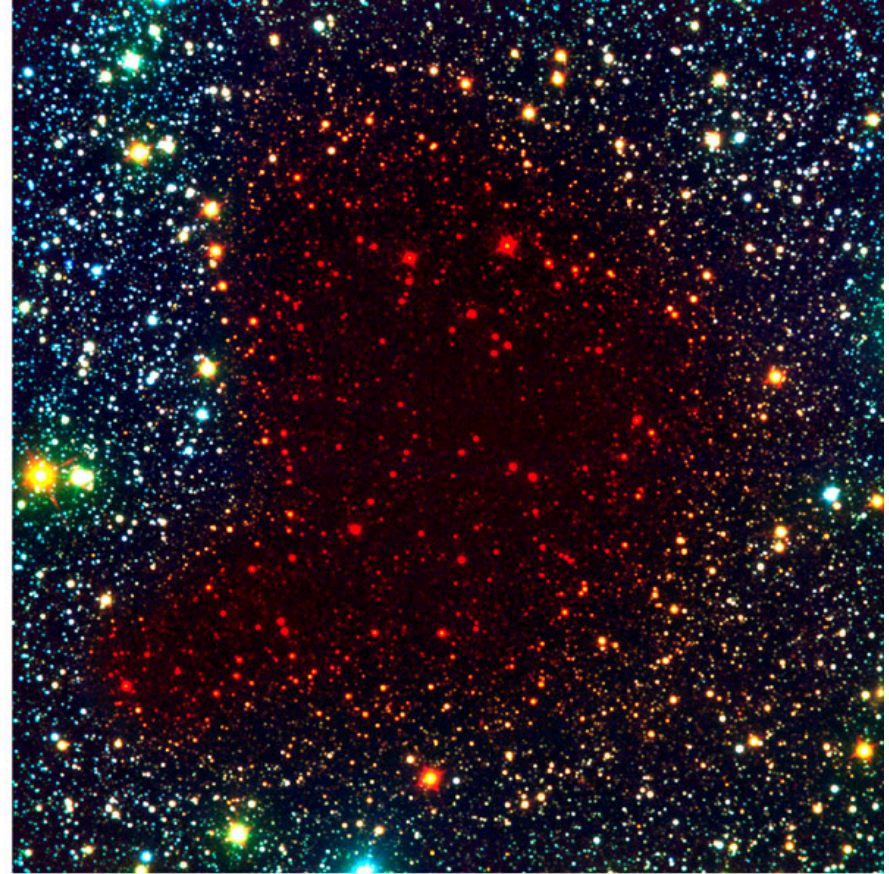
Zeilik Fig 15-5

Near-infrared Observations

- The extinction drops as the wavelength increases
- Therefore observations at near-infrared wavelengths are good for seeing through dust obscuration
- Near-infrared wavelengths are 1-3 μm (J,H & K filters)



B, V, I



B, I, K

Pre-Collapse Black Cloud B68 (comparison)
(VLT ANTU + FORS 1 - NTT + SOFI)

Dust Emission

- Dust grains in interstellar space are usually at a temperature of about 30 K
- Hence, they emit at around $100 \mu\text{m}$ which is at far-infrared wavelengths
- If dust grains are near a hot star then they can get heated up to around 300 K
- Then they emit at mid-infrared wavelengths, i.e. $\sim 10 \mu\text{m}$

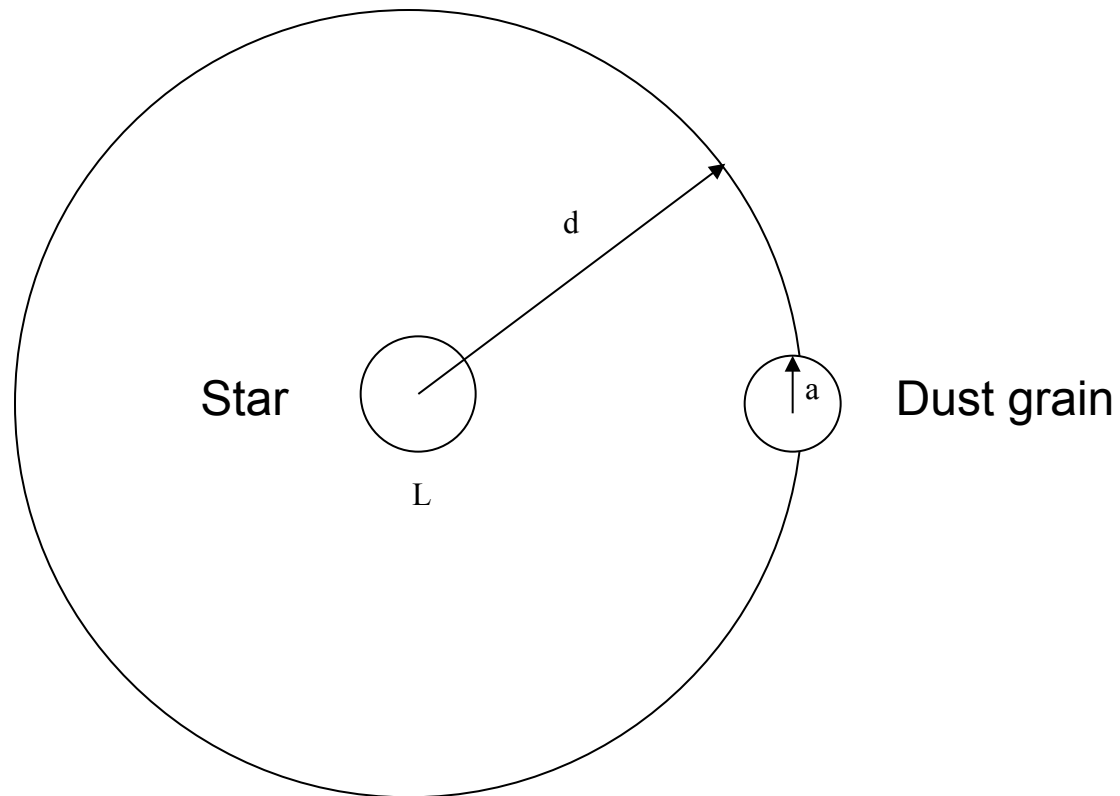


M8 nebula
in the mid-
infrared at
8-20
microns

Courtesy NASA/JPL-
Caltech

Temperature of a dust grain

- Consider a grain with radius, a , at distance, d , from a star of luminosity, L .



- Equate fraction of star's luminosity absorbed by grain with blackbody emission from the grain

$$\frac{\pi a^2}{4\pi d^2} L \approx 4\pi a^2 \sigma T^4$$

$$T \approx \left(\frac{L}{16\pi\sigma d^2} \right)^{\frac{1}{4}}$$

Star Forming Regions

- When stars form the dust in the molecular clouds gets heated up by the new stars
- Hence, star forming regions are bright infrared sources, in particular where massive, hot stars are being born



NASA Spitzer 24 microns



M31 NASA Spitzer 24, 70, 160 microns

Summary

- Interstellar dust is responsible for extinction and reddening of starlight at optical and ultraviolet wavelengths
- Near-infrared is used to see through the dust
- Mid-infrared and far-infrared is used to see emission from warm and cool dust