Interstellar Dust

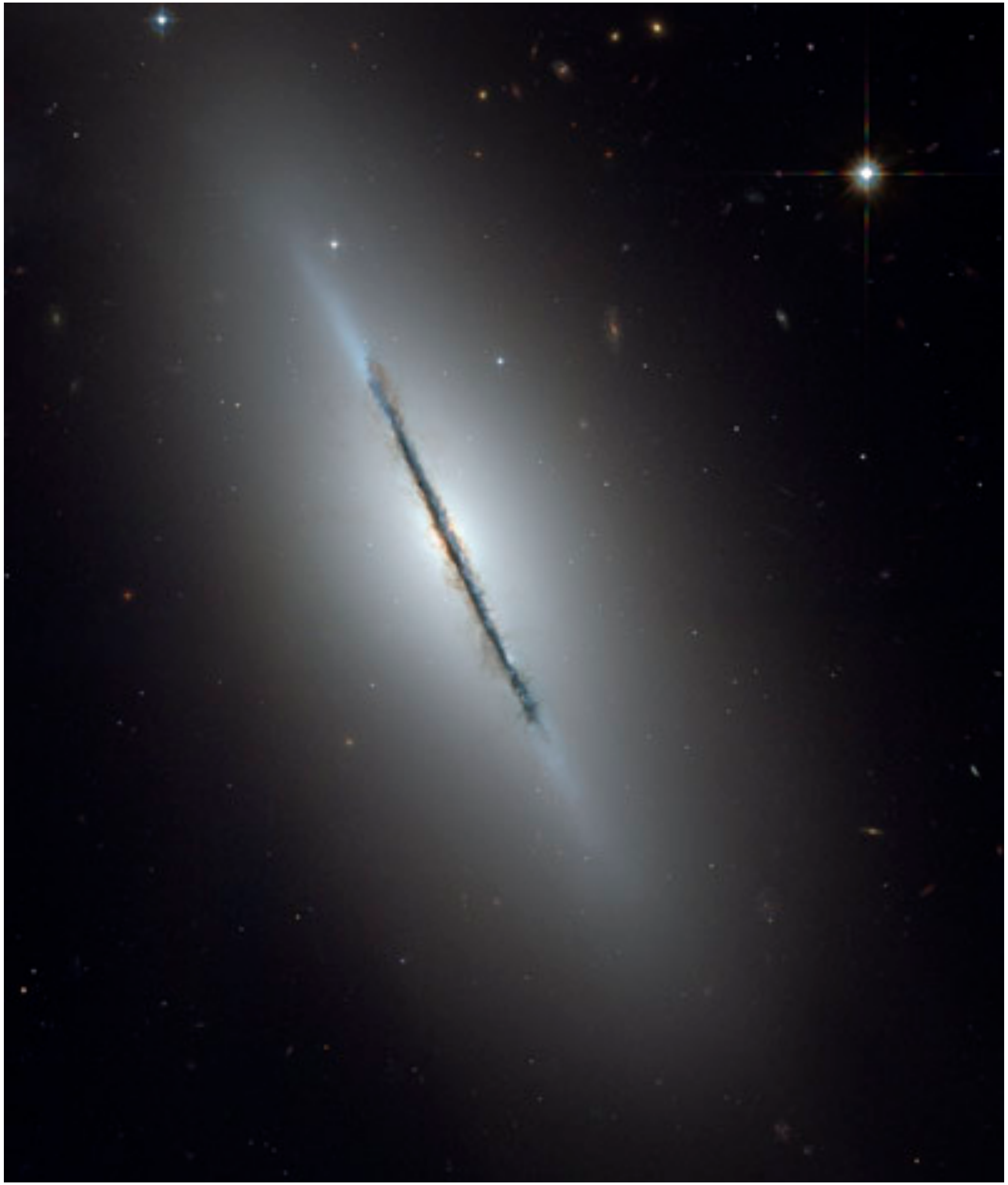
- Interstellar extinction
- Interstellar reddening
- Dust emission

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. ~ λ 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)

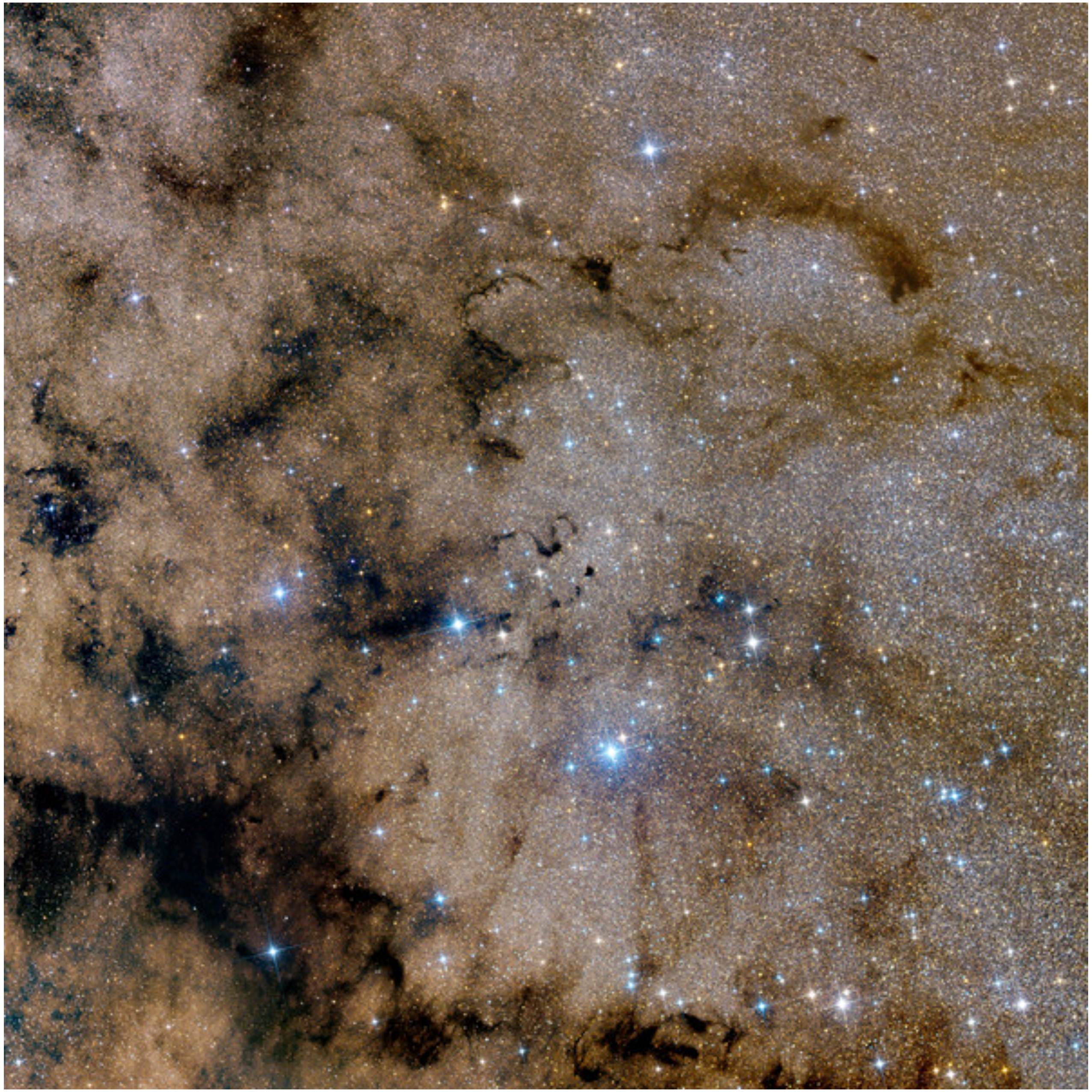
Visual Extinction

- 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

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

- In terms of absolute magnitude

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

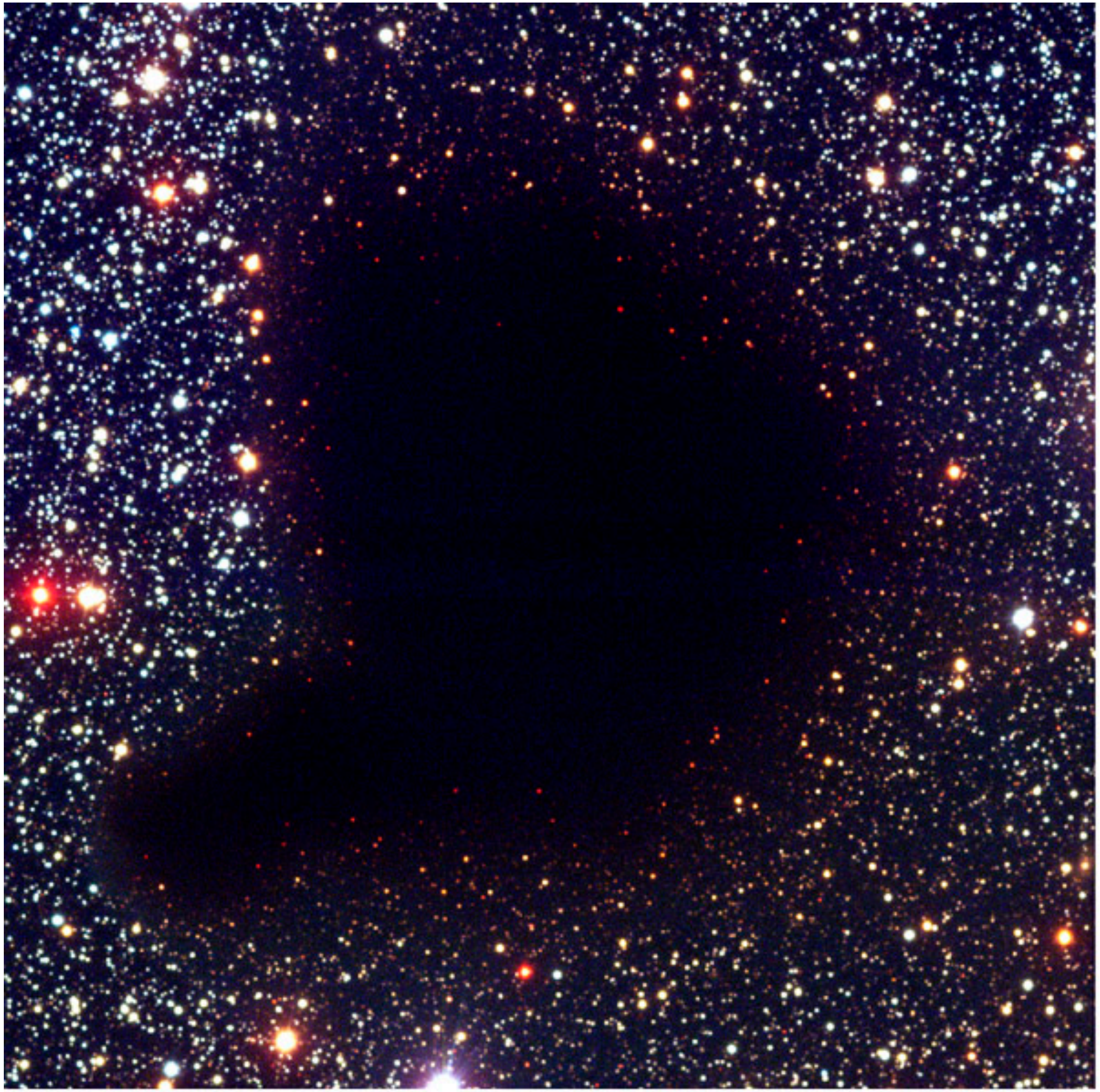


Interstellar dust clouds

www.glitteringlights.com

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

ESO PR Photo 02c/01 (10 January 2001)

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

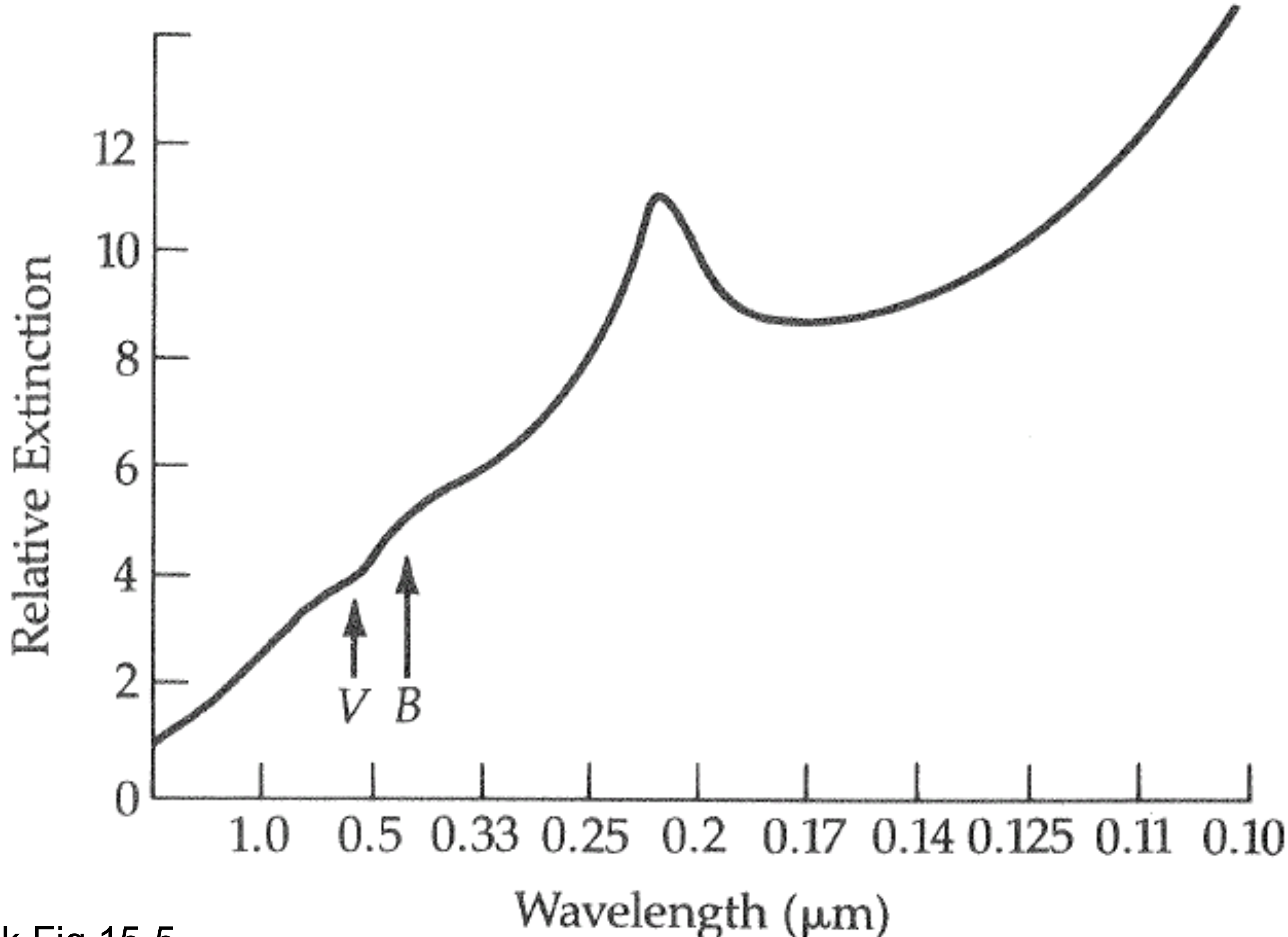
Extinction Law

- 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

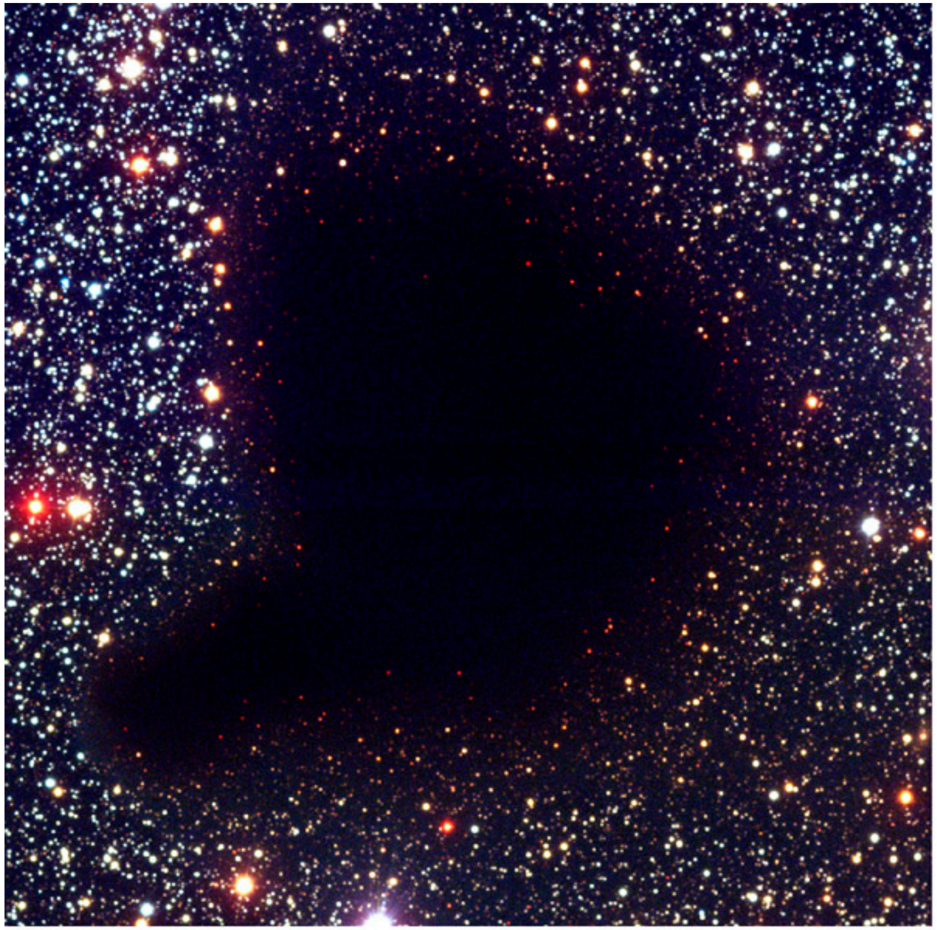
Interstellar extinction law



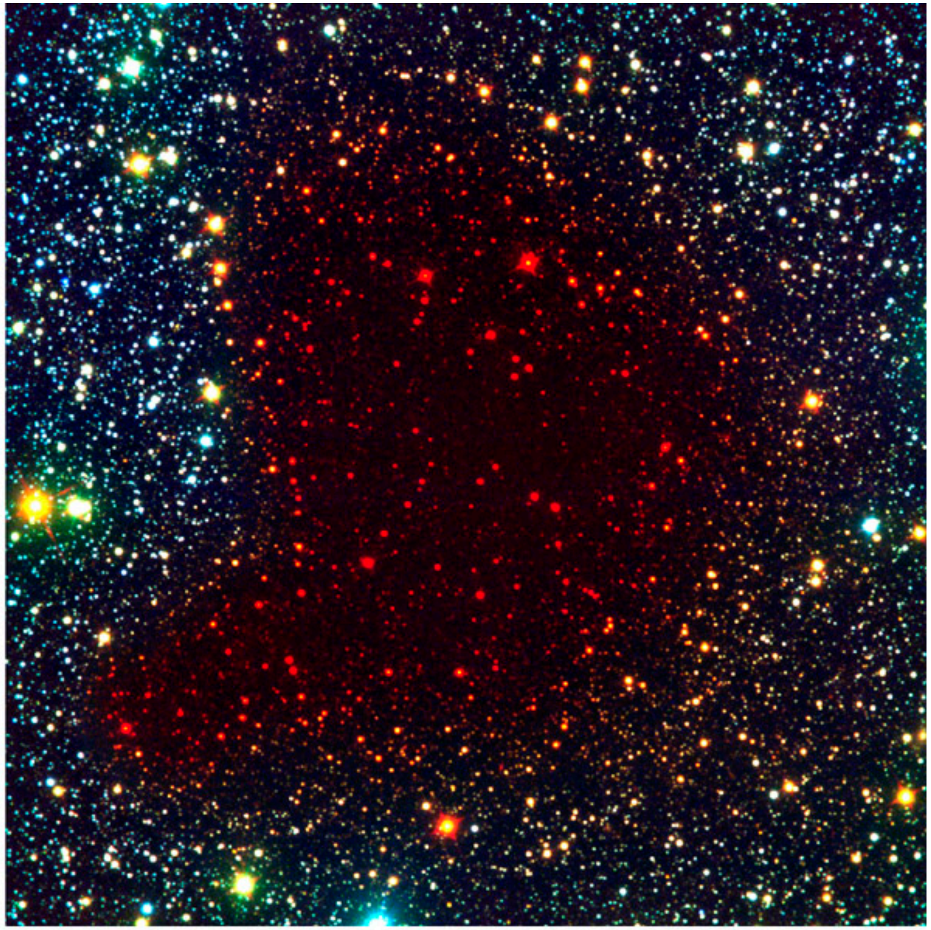
Zeilik Fig 15-5

Near-infrared Observations

- The extinction drops as the wavelength increases
- Therefore observations at near-infrared wavelengths are good for seeing through dust obscuration
- Common 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)

ESO PR Photo 02c/01 (10 January 2001)

Dust Emission

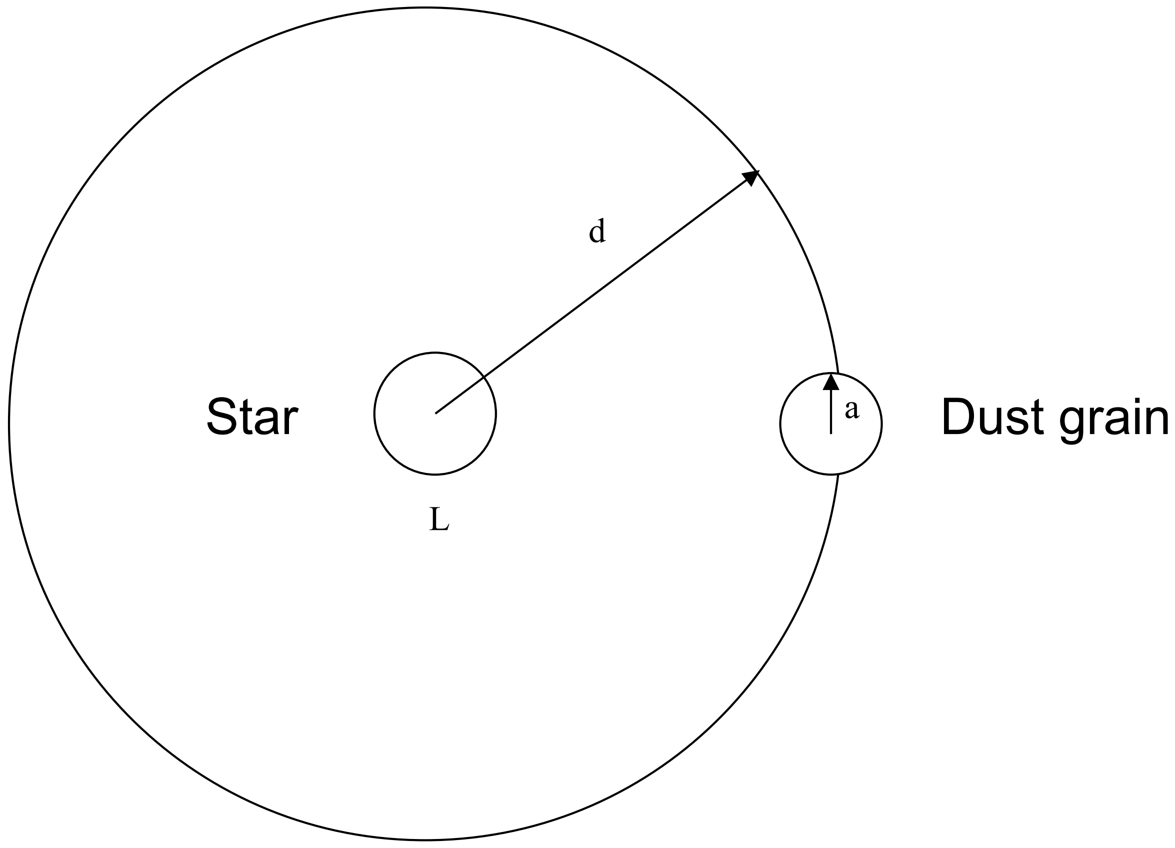
- Dust grains in interstellar space are usually at a temperature of about 30 K
- Hence, they emit at around 100 μm which is at far-infrared wavelengths
- If dust grains are near a hot star then they can get heated up to around 300 K
- Then they emit at mid-infrared wavelengths, i.e. ~10 μm

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

M 31

NASA Spitzer 24 microns

M31 NASA Spitzer 24, 70, 160 microns

What is dust made of?

- Still matter for debate
- Silicates and carbon-rich molecules likely
- Far-IR spectra show evidence for PAHs and hydration bands
- Dust collected from interplanetary space is irregular in shape with lots of voids between sub-particles

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