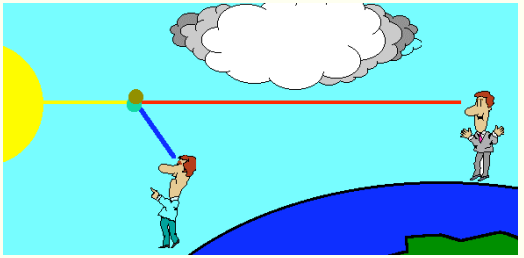
Natural Light

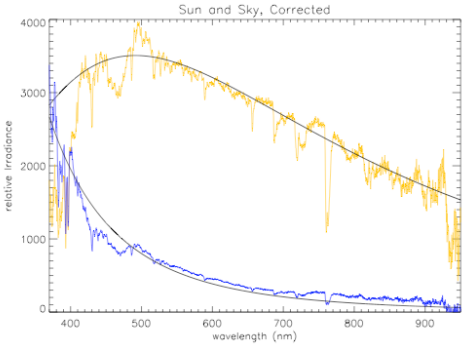
The Natural Appearance of Things

Why is the sky blue?

- Blue light more readily "scattered" by air molecules
  - called Rayleigh Scattering; *strong* function of wavelength
  - blue light in sky has been diverted from some other path
  - with some blue light missing, sun looks yellow/orange



The spectrum of the blue sky



The sky (blue curve) has a spectrum that gets steeper and steeper towards the blue/violet end of the visible spectrum.

Shown on top of the blue curve is a model that goes according to theory: $1/\lambda^4$

The orange curve is the spectrum of a white piece of paper in the sun

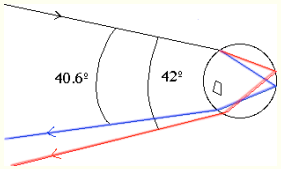
Is the night sky blue too?

- You bet! Just too dim to perceive
  - time exposure at night under moonlight shows this

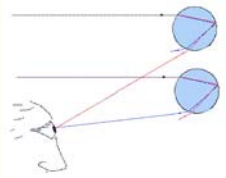
You can find blue from scattering in other circumstances as well: water, glaciers, astrophysical reflection nebulae…

Rainbows, Halos, Sun-dogs, and More…

- Rainbows come from the interaction of sunlight with round water droplets
  - preferred single-reflection path with ~42° deflection angle
  - see http://mysite.verizon.net/vzeoacw1/rainbow.html
    - drag incoming ray, and you get a stationary behavior at 42°
  - rainbow arc always centered on *anti-solar* point
  - different colors refract at slightly different angles
    - owes to differences in *refractive index* for different colors



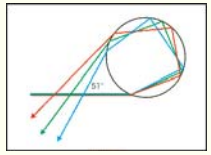
single bounce; red & blue paths different



red appears higher in sky than blue

Rainbows come in pairs…

Beautiful double rainbow in Zion National Park. The primary is brighter, and the color sequence is reversed from that seen in fainter secondary.



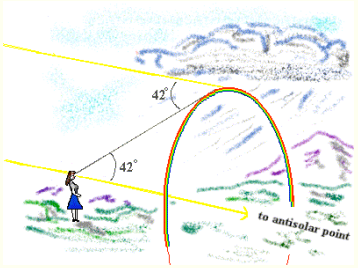
Secondary rainbow has two reflections. Red now appears *lower* than blue in the sky.

Area between rainbows often seen to be darker than elsewhere.

Note: rainbow can exist in foreground.

Questions

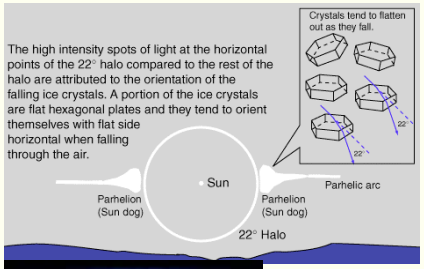
- Which general direction will a rainbow be found in the evening?
- Why don't you see rainbows during the middle of the day?



The halo, and sun-dogs

- 22° halo around sun due to hexagonal ice crystals
  - often more noticeable around moon at night (less glare)
- Sun-dogs (parhelia) join halo, level with sun
  - from *horizontally* situated ice crystals
    - akin to leaves falling in stable horizontal orientation
  - colored due to refractive dispersion through ice crystal

Sun-dog geometry



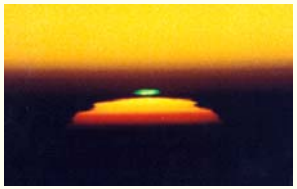
Antarctic skies: lots of ice…

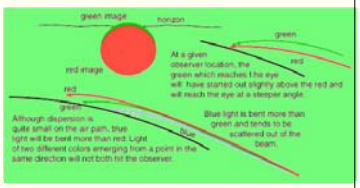
Glorys and Heiligenschein (shadow-hiding)

- A circular rainbow about the anti-solar direction is called a *glory*
  - Sometimes 2–3 colored rings
  - often see shadow in middle
  - water droplet phenomenon
- The anti-solar point may also get bright due to shadow-hiding
  - called heiligenschein
  - often see from airplane over textured terrain
  - no, the person in the photo is *not* an angel

The Green Flash

- The atmosphere acts like a mild prism: the refractive index varies slightly with wavelength
- Exaggerated low on horizon
- Different colors bent different amounts by atmosphere
  - the whole sun is bent 0.6° at the horizon
  - it has actually set before its refracted image sets!
- Red image sets first, followed by green
  - the blue has long been scattered away





References and Assignments

- References
  - Lynch & Livingston's *Color and Light in Nature*
  - Minnaert's *Light and Color in the Outdoors*
- Assignments
  - Read Chap. 27 pp. 515–526
  - Read Chap. 28 pp. 544–547
  - Read Chap. 34 pp. 671–674; skim rest as needed/interested
  - HW8, due 6/06: 30.E.42, 27.E.10, 27.E.11, 27.E.15, 27.E.20, 27.E.29, 28.E.31, 28.E.33, plus four more required problems posted on website
  - Last Q/O due Friday 6/06 by midnight