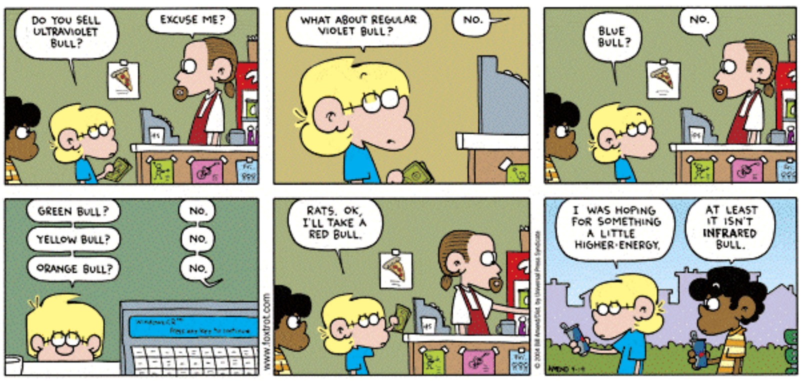
April 19, 2013 Physics 132 Prof. E. F. Redish

- **Theme Music:** **The Rolling Stones**
  Paint it Black
- **Cartoon:** **Bill Amend**
  FoxTrot



Light: Three models

- Newton's particle model (rays)
  - Models light as bits of energy traveling very fast in straight lines. Each bit has a color. Intensity is the number of bits you get.
- Huygens's/Maxwell wave model
  - Models light at waves (transverse EM waves). Color determined by frequency, intensity by square of a total oscillating amplitude. (Allows for cancellation – interference.)
- Einstein's photon model
  - Models light as "wavicles" == quantum particles whose energy is determined by frequency and that can interferer with themselves.

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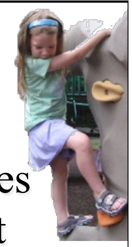
Foothold Ideas: The Photon Model



- When it interacts with matter, light behaves as if it consisted of packets (photons) that carry both energy and momentum according to:

$$E = \hbar\omega \qquad p = \hbar k \qquad \hbar = \frac{h}{2\pi}$$

$$E = hf \qquad p = \frac{E}{c} = \frac{h}{\lambda}$$

with $hc \sim 1234$ eV-nm.

  – These equations are somewhat peculiar. The left side of the equations look like particle properties and the right side like wave properties.

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Line Spectra

- When energy is added to gases of pure atoms or molecules by a spark, they give off light, but not a continuous spectrum.
- They emit light of a number of specific colors — *line spectra.*
- The positions of the lines are characteristic of the particular atoms or molecules.

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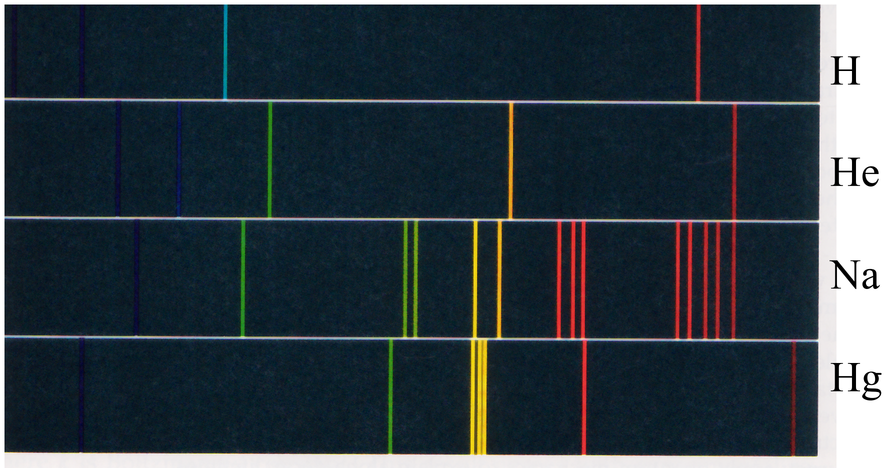
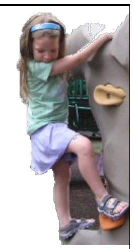
Line Spectra



Foothold Ideas: The Nature of Matter



- Atoms and molecules naturally exist in states having specified energies. EM radiation can be absorbed or emitted by these atoms and molecules.
- When light interacts with matter, both energy and momentum are conserved.
- The energy of radiation either emitted or absorbed therefore corresponds to the difference of the energies of states.

Implications

- This property of matter lets us do some rather remarkable things:
  - – chemical flame tests
  - – identify the composition of the sun and distant stars
  - – identify the composition of a plume of smoke emitted from a smokestack
  - – determine the relative composition of atoms in a rock and therefore determine its source

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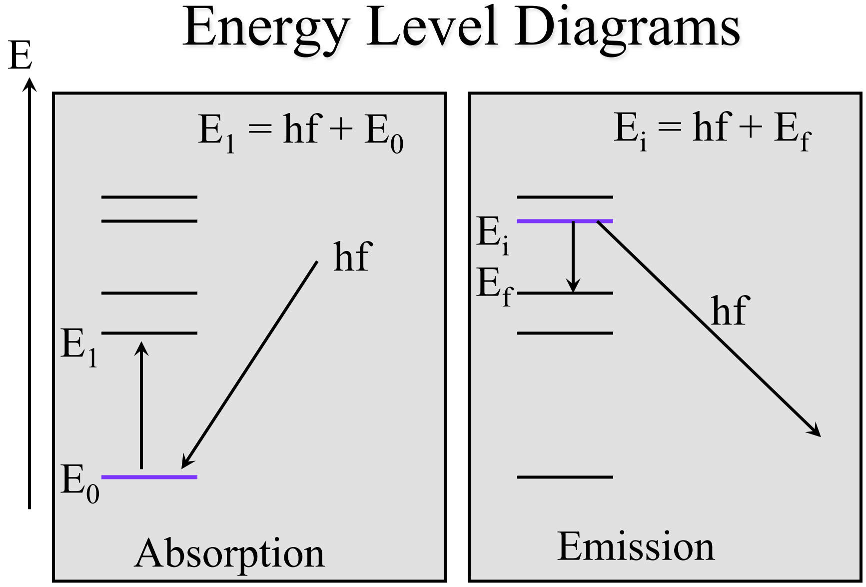
Energy Level Diagrams



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