Lec 5: 24 JAN 12  ASTR 130 - Introductory Astronomy II  (Chapter 5)

LAST TIME - Continuous Spectrum & Thermal Emission
• Photons and the Dual Nature of Light
• Continuous, Absorption, and Emission Spectra

TODAY - Atoms and Spectroscopy
• How are spectral lines formed?
• Structure of Atoms

THURSDAY – Spectroscopy & Astronomical Instrumentation
• Doppler Effect
• Instruments & Detectors

Composition and Structure of Matter
• Atoms and Elements
• Molecules and Compounds
• Structure of an Atom
  – Electron (-) orbits Nucleus (+) due to attractive force (analogy with gravity)
  – Nucleus consists of Protons (+) and Neutrons (0) [what holds it together?]
• Ions and Isotopes

4 Phases of Matter
T increasing -------> <------ P increasing
SOLID LIQUID GAS PLASMA
melt-> vaporize-> ionize->
<->fuse <-condense <-recombine
• e.g. water ice -> liquid water -> steam ->
  (protons, electrons, and O^+ ions)
• most of the universe is in the PLASMA state

How Do Atoms Produce Emission and Absorption Lines?
• Atoms can be energized, or EXCITED
  – electrons normally in “ground state”
  – when energy absorbed, electrons move “up” to higher energy levels
  – only specific energies are allowed!
• How do they get excited?
  1. Collisions with other atoms, ions, electrons, etc
  2. Absorption of electromagnetic radiation (photons)

Continuous, Emission, and Absorption Spectra: How Are They Formed?

4 Phases of Matter
T increasing -------> <------ P increasing
SOLID LIQUID GAS PLASMA
melt-> vaporize-> ionize->
<->fuse <-condense <-recombine
• e.g. water ice -> liquid water -> steam ->
  (protons, electrons, and O^+ ions)
• most of the universe is in the PLASMA state

How Do Atoms Produce Emission and Absorption Lines?
• Atoms can be energized, or EXCITED
  – electrons normally in “ground state”
  – when energy absorbed, electrons move “up” to higher energy levels
  – only specific energies are allowed!
• How do they get excited?
  1. Collisions with other atoms, ions, electrons, etc
  2. Absorption of electromagnetic radiation (photons)
• Atoms don’t stay excited for very long? How do they DE-EXCITE?
  1. Collisions with other atoms, ions, electrons, etc
  2. Emission of electromagnetic radiation (photons)

• Both emission and absorption only at energies that correspond to DIFFERENCE between 2 energy levels (therefore specific wavelength)

• Why only certain frequencies/wavelengths? energy ∝ frequency for a photon

Why do Atoms Have Energy Levels?
• attractive force between electrons and nucleus; electrons must keep moving to stay in orbit
• unlike gravity, not all orbits are possible
• allowed orbits satisfy the condition $E=E_0/n^2$

for Hydrogen:

<table>
<thead>
<tr>
<th>n</th>
<th>Energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>10.2</td>
</tr>
<tr>
<td>3</td>
<td>12.1</td>
</tr>
<tr>
<td>4</td>
<td>12.8</td>
</tr>
<tr>
<td>∞</td>
<td>13.6</td>
</tr>
</tbody>
</table>

Why Are Only Certain Orbits Allowed?

electrons have their own wavelength
only orbits that have an integer number of complete wavelengths are stable

demo: guitar

The Hydrogen Atom and Spectrum

• Energy levels different for different elements
• So each element has a unique “fingerprint” of spectral lines (emission and absorption same)

Absorption Spectrum of (mostly) Hydrogen

Hβ 486
Hγ 434
Hδ 410

Continuum

Intensity

300 400 500 600 700
Blue Wavelength (nm) Red
Solar spectrum shows Hydrogen and Helium, but also many other absorption lines, which we now know are due to other elements!