The Universe

When and where did the Universe originate?
The Big Bang
The Universe

- **Universe** - all the space, matter, and energy that exists in any place
  - Came into existence approximately 13.7 billion years ago with the Big Bang
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- **Big Bang** - states that all matter and energy started out concentrated in a small area and after a gigantic explosion, matter began to organize into subatomic particles and atoms.
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Evidence of the Big Bang

1. **Background Radiation** - left over energy created by the explosion found in all parts of the Universe

   • Scientists have found evidence of long wave radiation [microwaves] that come from all directions in the Universe
Background Radiation
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Evidence of the Big Bang

2. **Doppler Effect** - the apparent wave length shifting of electromagnetic energy caused by the relative motion between the energy source and the observer
Doppler Effect - Train in Motion
Doppler Effect - Car Horn
• **Electromagnetic Energy** - energy that is radiated through space in the forms of transverse waves.
Each element gives off an electromagnetic spectral line [signature]

Spectral Lines for Hydrogen
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- When scientists study energy coming off a celestial object they can infer:
  - Composition of the object
  - Direction of movement
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• Positions of the colored lines [spectral lines] shift as they studied stars and galaxies
  • **Blue Shift** - when Earth and the celestial object are coming together the spectral lines move towards the blue wavelength
  • **Red Shift** - when Earth and the celestial object are moving apart the spectral lines move towards the red wavelength
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Red Shift vs. Blue Shift
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Electromagnetic Spectrum

<table>
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<tr>
<th>Gamma rays</th>
<th>Ultraviolet</th>
<th>Infrared</th>
<th>Microwaves</th>
<th>Radio waves</th>
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</thead>
<tbody>
<tr>
<td>X rays</td>
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</table>

Decreasing wavelength

Visible light

Violet | Blue | Green | Yellow | Orange | Red

Increasing wavelength

(Not drawn to scale)

Earth Science Reference Tables
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- Normal
- Red Shift Moving Away
- Blue Shift Moving Towards
Expanding Universe