The History and Philosophy of Astronomy

(Lecture 20: Perspective: The Victorian Universe)

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General Timeline

- **Enlightenment** (1750-1830)
- **Victorian Age** (1830-1901)
- **Expressionism** (early 20th cent.)
General Timeline

William Herschel  
Enlightenment (1750-1830)

Earl of Rosse  
Victorian Age (1830-1901)

Einstein  
Early 20th cent.
The Victorian Age (1830-1901)

- Age of Contradictions!

- destitute poverty
- industrial vigor
The Victorian Age (1830-1901)

- Reign of Queen Victoria (1837-1901)
- Epoch of Imperialism
- Vigorous economic expansion, based on industrialized production
The Victorian Age (1830-1901)

• The Great Exhibition 1851

• London, Crystal Palace
Victorian Age: Thermodynamics

- Conservation of energy!
- Increasing entropy: From order to chaos!
Great Achievement: Stellar Parallax!

- Bessell 1838: 61 Cygni, $d = 10.3$ lightyears

\[ d = \frac{1}{p} \]

$p =$ parallax in arcseconds
\[ d =$ distance to star in parsecs
(1 parsec = 3.26 light-years)
Great Achievement: Stellar Spectra

- The Laws of Spectroscopy (Kirchhoff/Bunsen):
  - dark lines = absorption lines
  - bright lines = emission lines
Great Achievement: Discovery of Neptune 1846

• Existence of new planet *predicted* and discovered!
Baroque Astronomy in Perspective (1750)

- Status of knowledge on:
  - concept of space
  - concept of time
  - nature of stars
  - concept of motion modern (Newton)
  - Architecture of Solar System modern (Newton)
Victorian Astronomy in Perspective (1900)

• Status of knowledge on:
  - spatial structure of universe
  - architecture of stellar system (Milky Way)
  - age of the universe
  - stellar distances towards modern (several lightyears)
  - nature of stars towards modern view
19th Century: Spatial Structure of Universe

• infinite, 3-dimensional Euclidean space

• Cartesian coordinates \((x,y,z)\)

• Q: Is space full (no vacuum), or (partially) empty?
19th Century: Spatial Structure of Universe

- Q: Is space full (no vacuum), or (partially) empty?

- all of space pervaded by invisible ether!
Architecture of Stellar System

William Parsons, 3rd Earl of Rosse (1800-67)

“Leviathan of Parsonstown”
Architecture of Stellar System

- His sketch of M51 (1845): First Spiral Nebula
- Speculate: -- Galaxy in rotation?
  -- A galaxy (system of stars), or gaseous nebula?
Architecture of Stellar System

• Two basic models:

One-island universe

Many-island universe (Kant)
Architecture of Stellar System

- Jacobus Kapteyn (1851-1922)
- Professor at Groningen University (The Netherlands)
- Census of the sky
- ‘The Kapteyn Universe’ (Universe = Milky Way)
Architecture of Stellar System

- one-island universe (Milky Way = Universe)
- Solar System close to the center
- surrounded by infinite (starless) void
• 19th century astronomers only saw nearby stars, because of interstellar extinction (dust)!
Interstellar Dust

- Interstellar dust only discovered in 20th century!
Three World Systems: Plenum vs Vacuum

- Aristotelian
  - space: finite
  - matter: finite

- Stoic
  - space: infinite
  - matter: finite

- Epicurean
  - space: infinite
  - matter: infinite
Problem with Victorian universe:
Gravitational Instability!

- Ad hoc fix: Have to assume that gravity does not obey inverse-square law at large distances!
19th Century View: Age of the Universe

• Solar System (and the stars) have a finite age (millions to billions of years)

• But what about the universe as a whole?

• Recall view at end of Baroque Period (~1750)!
Baroque: Creation of Universe

• before creation: empty space and time, no matter!
Baroque: Creation of Universe

• after creation: empty space and time with matter everywhere!
19th Century View: An Eternal Universe

- space, time, and (finite) matter have existed forever!
19th Century View: An Eternal Universe

• (finite) matter was more diffuse in the past!
19th Century View: Age of the Universe

- Solar System (and the stars) have a finite age (millions to billions of years)

- But what about the universe as a whole?

- A: Universe as a whole is eternal!

- Put differently: The contents of the universe is constantly changing (evolving), but the universe as a whole is not!

- Conceptually, this is not convincing!
Great Task Ahead: Origin of Universe and Time!

- The Big Bang!
Olbers’ Paradox: Darkness at Night

- Wilhelm Olbers (1758-1840)

- German physician and amateur astronomer

- Olbers asks (1823):
  “In an infinite and eternal universe: Why is the sky dark at night?”
Victorian Universe: Resolve Olbers’ Paradox

- In universe with infinity of stars: No darkness at night!
Victorian Universe: Resolve Olbers’ Paradox

- In universe with infinity of stars: No darkness at night!
Victorian Universe: Resolve Olbers’ Paradox

- In universe with finite # of stars: Darkness at night!
Perspective: The Victorian Universe

• Successfully explained:
  - Sun and stars are made of normal matter
  - spectra of Sun and stars
  - distance scale of the stars

• New questions/problems:
  - How is an eternal universe consistent with finite Sun?
  - What is the true nature of the Spiral Nebulae (e.g., M51)?
  - What is true architecture of Milky Way?
  - Why does Milky Way not collapse to a point?
  - Physical nature of the stars (and planets)?

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