

ASTR 1020: Stars & Galaxies

April 18, 2008

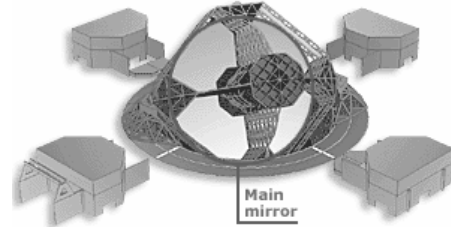
- Reading: Chapter 23; section 23.1-23.2.
- **Extra credit:** Fiske Planetarium shows every Thursday and SBO observing.

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Astronomy In the News

Corey Herrmann

THE OVERWHELMINGLY LARGE TELESCOPE



Cost: Projected to be one billion euros
Main mirror: At least 100 metres across
Timescale: It would take 15 years to build

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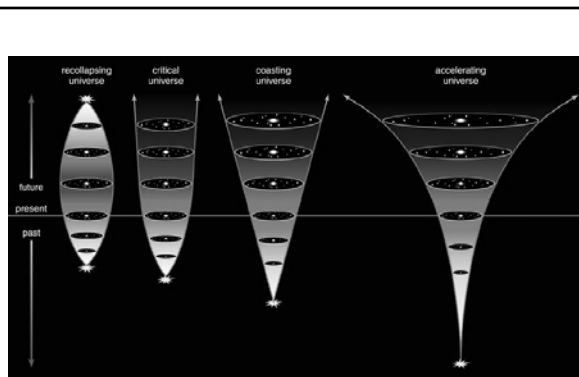
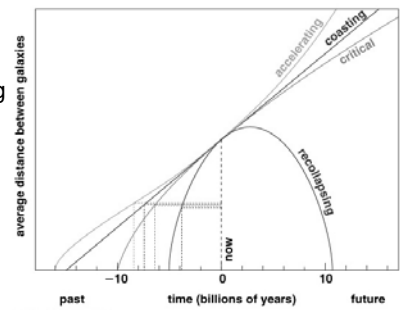
Today

- Chapter 22, Section 4: Dark Matter, Dark Energy, and the fate of the Universe
 - Preview of Chapter 23: The Creation of the Universe
- (the creation of all matter, light and energy)

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Dark Matter and the Fate of the Universe

- Expansion begins with the Big Bang
- Several different models for Past and Future



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What is the fate of the Universe?

- Recollapse: crushing heat, destruction of all matter, ?rebirth?
- Eternal expansion: cold, galaxies dimming
 - star formation slowing
 - everything winds up as a brown dwarf, black dwarf, neutron star or black hole

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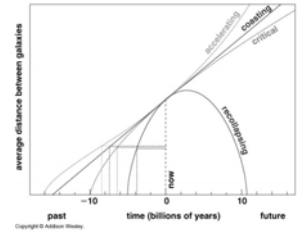
Some say the world will end in fire
 Some say with ice
 From what I've tasted of desire
 I hold with those who favor fire
 But if I had to perish twice
 I think I know enough of hate
 To say that for destruction ice
 Is also great
 And would suffice

-- Robert Frost

Clicker Question: Which universe predicts the largest age for the universe today?

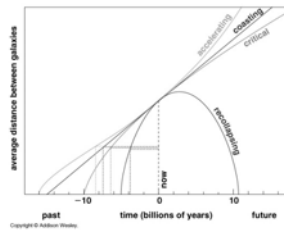
- a) Recollapsing
- b) Critical
- c) Coasting

(Ignore accelerating for now)



C) Coasting

- Age of the universe is how far to the left the curves hit the horizontal axis (distance between galaxies = 0)



Which is it?

Is there enough dark matter to recollapse the universe?

Baryonic matter: only a few percent of critical density

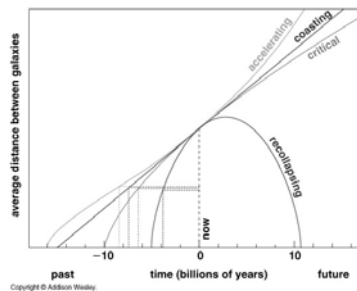
Dark matter: only about 25% of what is needed

Universe is in between the "coasting" and "critical" models

The Universe will expand forever

Clicker Question: If there was really ZERO dark matter in the universe, which model would be the closest to reality?

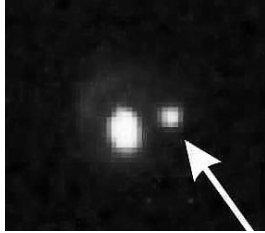
- a) Coasting
- b) Critical
- c) Recollapsing



- Baryonic matter is < 5 percent of the critical density.
- Closest model would be the Coasting Model (no deceleration from gravity).

A New Twist for the 21st Century

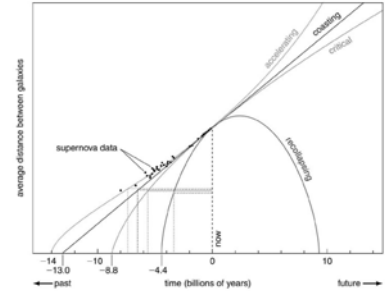
- White dwarf supernovae: standard candles at $z \sim 1$
- Explosions bright enough to see very far away



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Redshifts of the supernova plot their vertical position

- $Z=1$ means about halfway down from the "NOW" level
- expansion factor = $1+Z = 2$

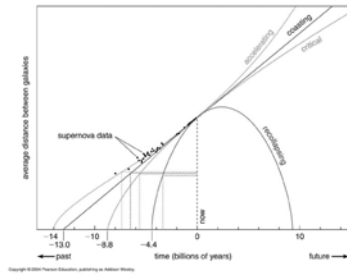


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Their brightness plots their horizontal position

Dimmer
= more distant
= longer ago

- Supernovae are DIMMER than expected for a coasting universe
- Universe is accelerating!



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How can the universe be accelerating???????

A force that counteracts gravity?

“Dark energy” – outweighs every other form of mass/energy!

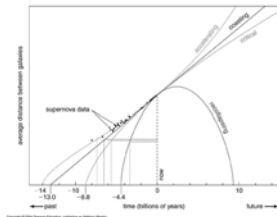
Truly an unknown force in all of physics!

(Read “Einstein’s Biggest Blunder” p 679)

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Accelerating model universe

- Longest time since Big Bang (14 billion years)
- Oldest stars are about 13 billion years old – other models fall short!
- Universe will expand forever still.....
- Will there be more surprises to come?????



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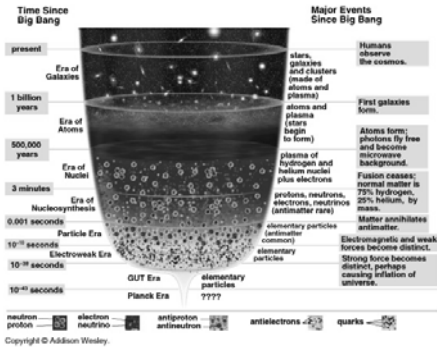
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Summary: Contents of Universe

- “Normal” Matter: ~ 4.4%
 - Normal Matter inside stars: ~ 0.6%
 - Normal Matter outside stars: ~ 3.8%
- Dark Matter: ~ 25%
- Dark Energy: ~ 71%

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Chapter 23: In the VERY Beginning



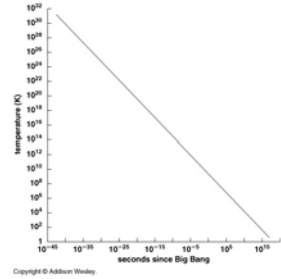
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Hot stuff!

Everything in the Universe was hotter at earlier times, and then cooled as it expanded

The temperature at the earliest times was more than the energy we create in particle accelerators

Cosmology at the earliest times is explored via particle physics!

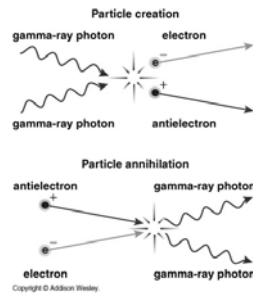


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Matter and Energy

- $E=mc^2$
- Matter and energy are the same, can transform from one to another

Matter + antimatter
 $\leftarrow \rightarrow$ photons



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