Sex in Space: Astronomy 330

134 Astronomy Building

This class (Lecture 3):

Expanding Universe

Next Class:

Origin of Elements

HW1 due tonight.

Music: *Galaxies*– Laura Veirs

Outline

- Pseudoscience vs. real science?
- Pseudoscience is very common in ET life, i.e. UFOs, crop circles, etc.
- Need to be able to identify the two for presentations.

- The early Universe– The origin of H
- The probable fate of the Universe

Presentations

- The presentation schedule has been decided by random selection.
- It is posted in the schedule section of the webpage.
- Make sure to check those dates ASAP.

Presentations

- Will be treated like a real talk.
- I will keep you to 12 minutes with up to 5 minutes of questions. (Peers should deduct points if too short, or I will.)
- Any speculative claims *MUST* have a scientific reference source.
  - Can't just claim that monkeys live on the Moon.

Presentations

- Can give presentation in any format you want.
- Over last few semesters:
  - 97.9% powerpoint/keynote/opd
  - 1% talking with pics from webpages
  - 1% dedicated webpage
  - 0.1% overhead slides
- If presentation is electronic, I want to see draft version 1-2 days in advance
  - Email me
  - Or, on netfiles, email me URL location
  - Or, bring in burned CD (present to me class BEFORE)
  - Or USB Flash Drive (present to me class BEFORE)

Oral Presentation

1. How relevant is the general topic to this class (e.g. search for extraterrestrial life)?
2. How interesting is the topic for the general class audience?
3. Rate the extent of the speakers knowledge on the topic?
4. Rate the quality of the overall presentation?
5. Does the research have a solid scientific basis?

These questions are rated 1-10 out of 10 scale by your peers!

Common Mistakes

- Too much text on a slide.
- Too long (only 2% are too short).
- Background graphics or color makes text hard to read.
- Reading the slides is boring, use as points but not the whole message.
- 12 minutes is not as long as it sounds.
- Example

Science

We especially need imagination in science. It is not all mathematics, nor all logic, but is somewhat beauty and poetry.

Maria Mitchell (1818 – 1889)
Astronomer and first woman elected to American Academy of Arts & Sciences

Scientific Thinking

- It is a natural part of human behavior.
- We draw conclusions based on our experiences.
- Progress is made through "trial and error."

Grouped

By yourself, write down, in only a few minutes, the definitions of :

1. Science
2. Pseudo-science

The Scientific Method

1. Make Observation
2. Ask a question
3. Suggest a Hypothesis
   - a tentative explanation
4. Make a prediction
5. Test
6. What are the results?
   - confirm, reject, or modify

These should be the same no matter who conducts the test

Hallmarks of Good Science

- Science seeks explanations for *observed* phenomena that rely solely on natural causes.
- Science progresses through the creation and testing of models of nature that explain the observations as simply as possible.
  ➔ Occam's Razor

Occam's Razor

- *Pluralitas non est ponenda sine necessitate* [Latin]
- Given two equally predictive theories, choose the simpler.

Or

– *The simplest explanation is usually the best.*

Hallmarks of Good Science

- Science seeks explanations for *observed* phenomena that rely solely on natural causes.
- Science progresses through the creation and testing of models of nature that explain the observations as simply as possible.
  ➔ Occam's Razor
- A scientific model must make testable predictions that could force us to revise or abandon the model.

Theory - a model that survives repeated testing

Very different usage than everyday speech!

Bad Scientific Practice

- **Pseudoscience** – masquerades as science, but does not follow the scientific rules of evidence
- **Not science** – establish "truths" through belief

Hallmarks of Pseudoscience

1. **Use of vague, exaggerated or untestable claims**
   - Misuse of apparently technical jargon to give claims with the superficial trappings of science.
   - Failure to give details of experiments, so they can be repeated.
   - No controls.

Adapted from wikipedia

Hallmarks of Pseudoscience

2. Over-reliance on confirmation rather than refutation

- Over-reliance on testimonial, anecdotal evidence or personal experience.
- Presents data that seems to support its claims while suppressing or refusing to consider data that conflict with its claims.
- Reversed burden of proof. In science, the burden of proof rests on those making a claim, not on the critic.
- Assertion that claims that have not been proven false must be true, and vice versa.

Adapted from wikipedia

Hallmarks of Pseudoscience

3. Lack of openness to testing by other experts

- Evasion of peer review before publicizing results. (typically they state that the peers are biased against the claims)
- Assertion of claims of secrecy or proprietary knowledge in response to requests for review of data or methodology.
- Requests money to see evidence

Adapted from wikipedia

Hallmarks of Pseudoscience

4. Personalization of issues

- Tight social groups can enhance the adoption of beliefs that have no rational basis. In attempting to confirm their beliefs, the group tends to identify their critics as enemies.
- Assertion of claims of a conspiracy on the part of the scientific community to suppress the results.
- Attacking the motives or character of anyone who questions the claims.

Adapted from wikipedia

Hallmarks of Pseudoscience

5. Use of misleading language

- Creating scientific-sounding terms in order to add weight to claims and persuade non-experts to believe statements that may be false or meaningless.
- Using established terms in idiosyncratic ways, thereby demonstrating unfamiliarity with mainstream work in the discipline.

Adapted from wikipedia

Compare/Contrast

Science	Pseudoscience
Findings are expressed primarily through scientific journals that are peer-reviewed and maintain rigorous standards for honesty and accuracy.	The literature is aimed at the general public. There is no review, no standards, no pre-publication verification, no demand for accuracy and precision.
Reproducible results are demanded; experiments must be precisely described so that they can be duplicated exactly or improved upon.	Results cannot be reproduced or verified. Studies, if any, are always so vaguely described that one can't figure out what was done or how it was done.
Failures are searched for and studied closely, because incorrect theories can often make correct predictions by accident, but no correct theory will make incorrect predictions.	Failures are ignored, excused, hidden, lied about, discounted, explained away, rationalized, forgotten, avoided at all costs.
As time goes on, more and more is learned about the physical processes under study.	No physical phenomena or processes are ever found or studied. No progress is made; nothing concrete is learned.
Convinces by appeal to the evidence, by arguments based upon logical and/or mathematical reasoning, by making the best case the data permit. When new evidence contradicts old ideas, they are abandoned.	Convinces by appeal to faith and belief. Pseudoscience has a strong quasi-religious element: it tries to convert, not to convince. You are to believe in spite of the facts, not because of them. The original idea is never abandoned, whatever the evidence.
Does not advocate or market unproven practices or products.	Generally earns some or all of their living by selling questionable products (such as books, courses, and dietary supplements) and/or pseudoscientific services (such as horoscopes, character readings, spirit messages, and predictions).

Adapted from http://maxwell.uncc.edu/mcorwin/Powerpoint/Distinguishing%20Science%20and%20Pseudoscience.htm

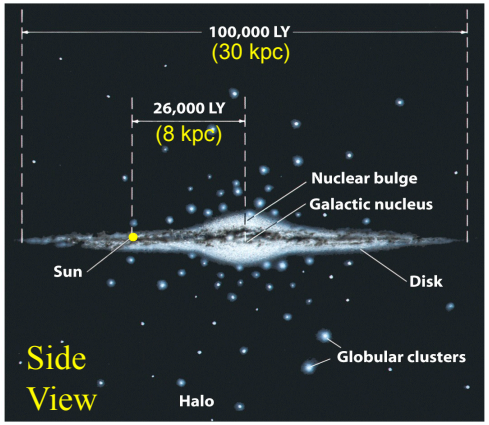
Grouped

- In groups of more than 3 and less than 5, discuss pseudoscience compared to science.
- Write a pseudoscience argument for something that one might find on a webpage pertaining to topics of this class (no more than 1 page). (i.e. make some pseudoscience up!)
  - One sheet for the group.

Example

http://www.stopabductions.com/

Our Galaxy



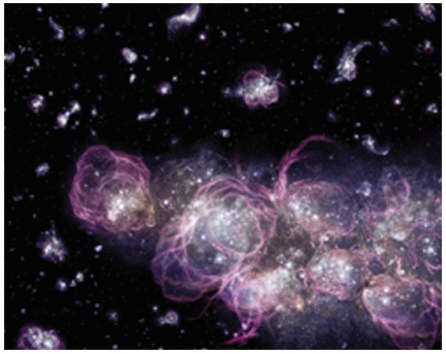
- Globular clusters– oldest stars
- Galactic nucleus– dense collection of stars (center of Galaxy)
- Nuclear bulge– mostly old stars, but very densely packed
- Spiral arms and the disk– mostly young stars and lots of dust
- Note position of the Sun, just over half way out.

Galaxy Song

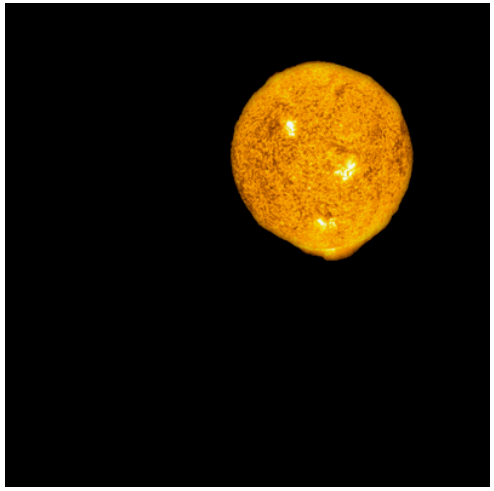
Monty Python's The Meaning of Life (1983)

Cosmology

- What is the Universe?
  - All the matter, energy, and spacetime we can ever detect
- **Cosmology** is the study of the origin, structure, and evolution of the Universe



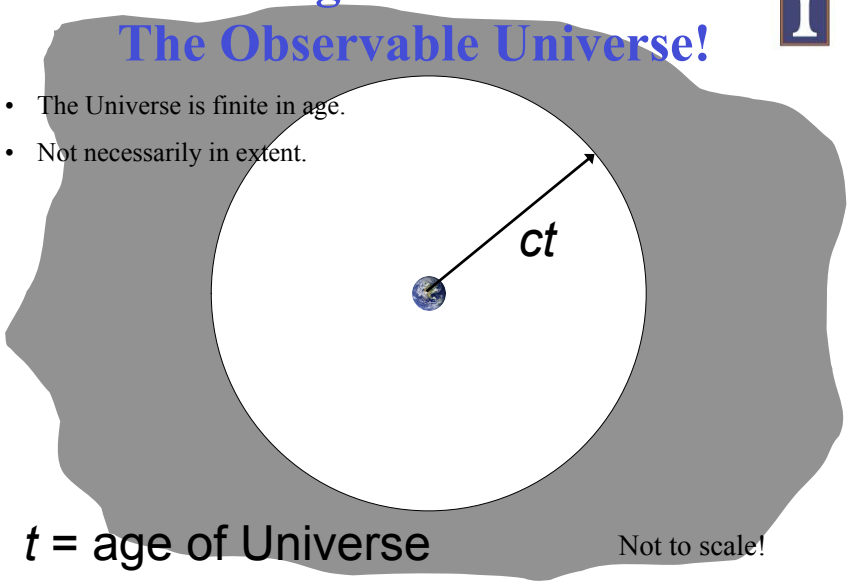
The Night Sky: Olber's Paradox



http://en.wikipedia.org/wiki/Olbers'_paradox

Looking Back in Time: The Observable Universe!

- The Universe is finite in age.
- Not necessarily in extent.



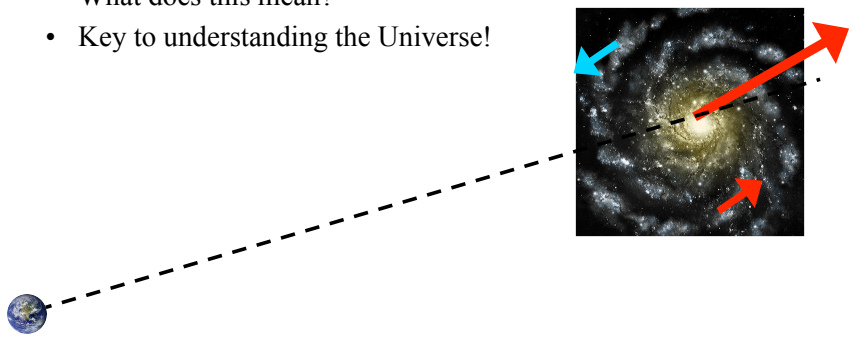
How are Galaxies Moving?

It's 1928 and Edwin Hubble is measuring how galaxies move. What does he find?

a) More galaxies receding than approaching.
b) More galaxies approaching than receding.
c) About equal numbers of each.

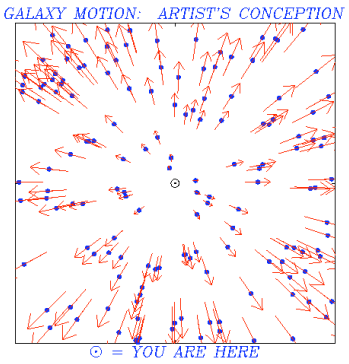
What Does This Mean?

- Most galaxies are moving away from us.
- The farther away, the faster they are moving away.
- Or $V = H_o \times D$
  - $H_o = 72$ km/s /Mpc
- What does this mean?
- Key to understanding the Universe!



Apply it?

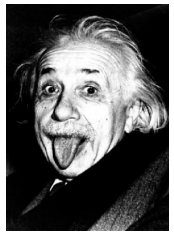
- In a homogenous Universe, what does the farther away the faster the galaxies move away mean?
- Draw it.



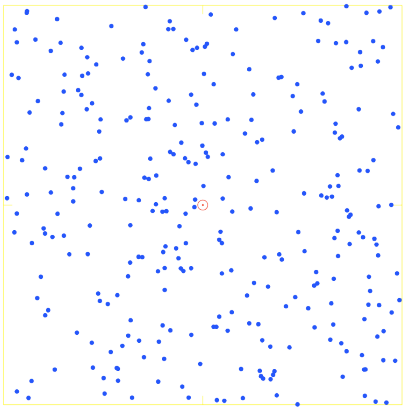
Interpretation: View of the Universe

Egoist view– We are at the center of the Universe.

Einstein's view– The Universe is expanding, and there is no center!



Gives the Impression of Being Special



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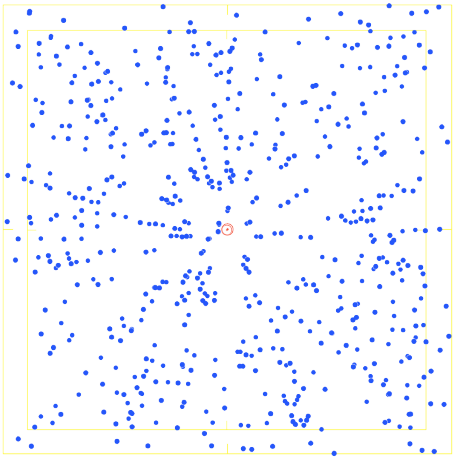

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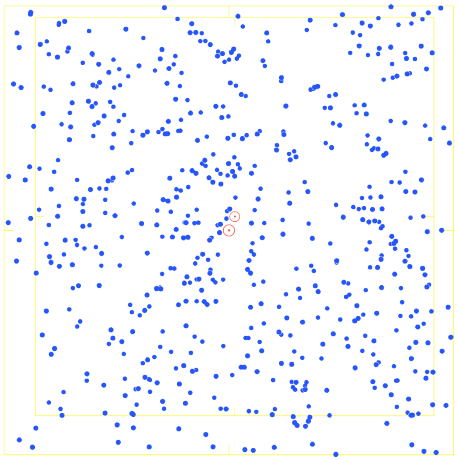

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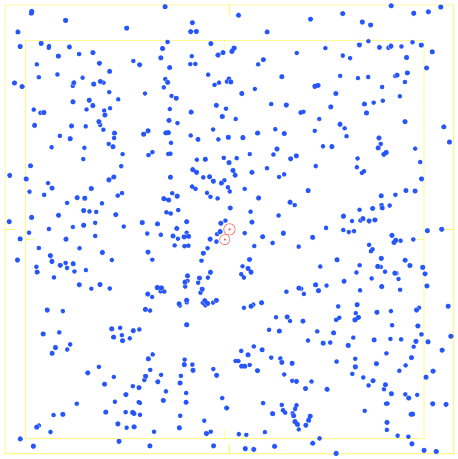
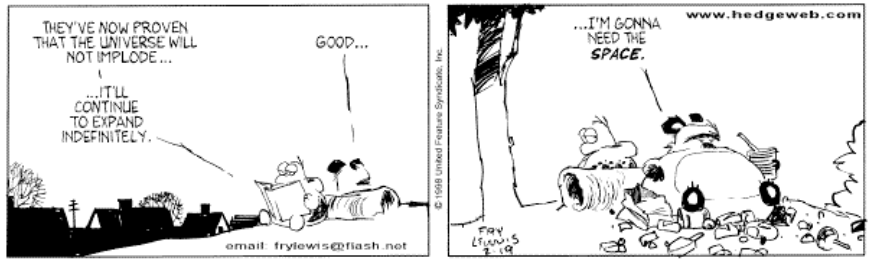


The Expanding Universe

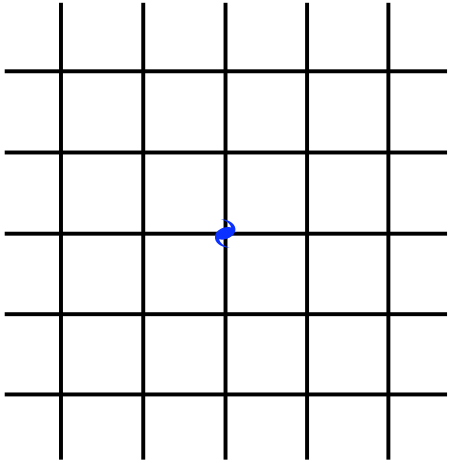
- To describe the motion of all the galaxies in the Universe, we use General Relativity (due to gravitation effects)
  - We'll talk about General Relativity more later, but it describes how the mass of objects (in this case all of the matter in the Universe) can distort space/time.

The Expanding Universe

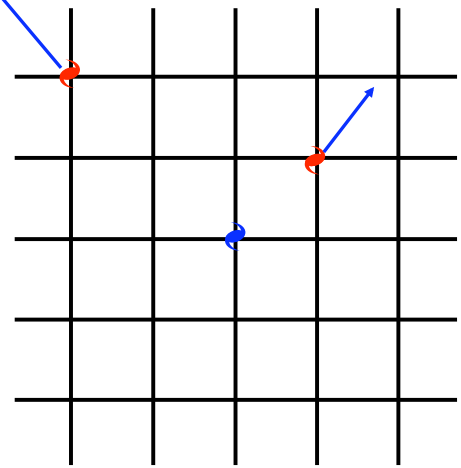
- To describe the motion of all the galaxies in the Universe, we use General Relativity (due to gravitation effects)
- General Relativity predicts that we live in an *expanding Universe*.
  - Einstein didn't buy it at first, so made a cosmological constant to get rid of it.
- In other words, space is stretching in all directions. This completely explains Hubble's Law.



Dude, The Universe is Expanding.



Wow. The Universe is Expanding.



Question

Nearly all galaxies are moving away from our Galaxy. What does this mean?

a) We are the center of the Universe.
b) We are actually the only moving galaxy.
c) No one wants to play with us.
d) All particles are repelling each other.
e) The Universe is expanding.

Hold on a minute there!

- Why don't we expand with the Universe?
- Other forces hold us together
  - Atoms - nuclear forces
  - Molecules & living beings – electromagnetic forces
  - Planets, stars, and galaxies – gravity
- But gravity can't hold galaxy superclusters together
  - Expansion grows stronger with distance (more expanding space)
  - Gravity grows weaker with distance (inverse square law)
- **Brooklyn isn't expanding!**

Brooklyn Is Not Expanding

Directed by
Woody Allen

Annie Hall (1977)

What do you think?

The Universe is expanding, how do you feel about that?

http://www.calresco.org/ewp/confuse.htm

A) 

B) 

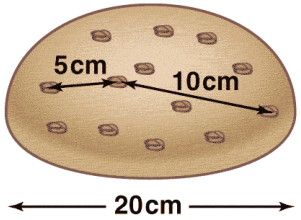
C) 

Expanding

- Hubble showed us that galaxies are moving away from us.
  - The farther, the faster
- This can imply an expanding Universe
- But, we aren't expanding, local forces hold us together

Analogy– Raisin Bread

The raisins are like galaxies.



Raisins stay the same size, like Brooklyn.

Question

The Universe is expanding, but we are not. Why?

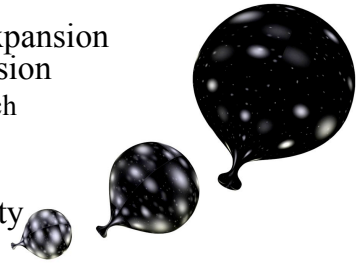
a) We are special.
b) We are grounded by our understanding of the Universe.
c) We are held together by stronger local forces.
d) What are you talking about, we are expanding.
e) The Universe is just no longer expanding.

~~Expanding into What?~~

~~What is North of the North Pole?~~

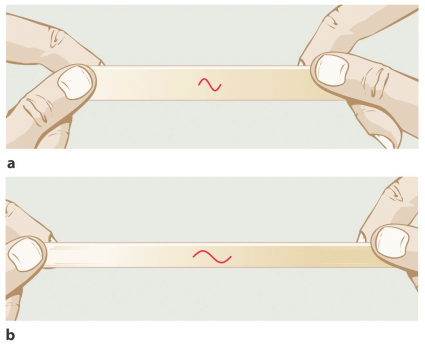
Common Misconception

- Its common to think of the expansion of the Universe like an explosion
  - Galaxies hurled away from each other through space
- This is incorrect!
- Einstein's Theory of Relativity tells us that spacetime itself is expanding!
  - Like an inflating balloon



Analogy - Rubber Band

- Spacetime expands, like stretching a rubber band
- Not only do distances grow…
- Even the photons' wavelengths get stretched!
  - Increasing wavelength = redshift!
  - **Cosmological redshift**



Reality

- The analogies are just to help us visualize, don't get stuck in the specifics.
- The Universe has no center.
- The Universe has no edge.
- Concept of time and space began with the Universe, can not apply the concepts so easily.

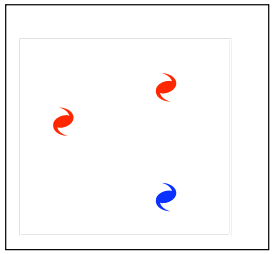
http://universe.gsfc.nasa.gov/images/reach-for-the-universe.jpg

Living in an Expanding Universe

Consider a large "box" containing many galaxies

- Total mass in box today: M_{today}
- Total volume in box today: V_{today}
- ***Density today*** $= M_{today} / V_{today}$

The Universe box



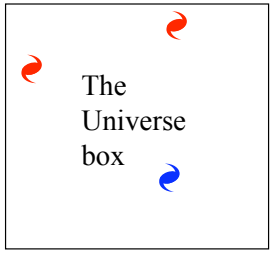
Tomorrow

How does the density of the Universe change with time?

Living in an Expanding Universe

How does the density of the Universe change with time?
As the Universe expands:

- $M_{tomorrow}$ stays the same
- $V_{tomorrow}$ becomes larger
- Density $M_{tomorrow}/V_{tomorrow} \Rightarrow$ *smaller*



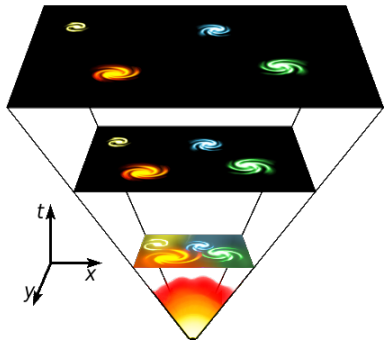
$M_{tomorrow}/V_{tomorrow} < M_{today}/V_{today}$

Density changes with time!

- Universe was denser in the past
- Universe will be less dense in the future

Putting it all together:

1. The Universe is expanding
2. Earlier Universe was more dense
3. Earlier Universe was hotter.



The origin of the Universe can be described by the idea of the Big Bang. Where did the Big Bang happen? The Universe is homogenous & isotropic.

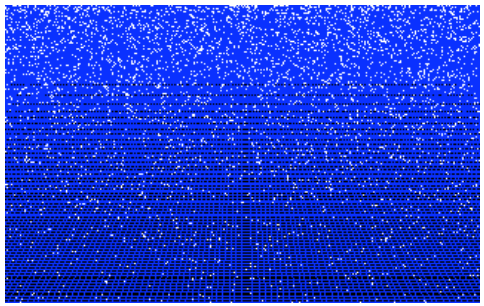
Georges Lemaître

The Biggest Bang since the Big One

- Occurred everywhere at once
- Not an explosion into empty space.
- The Universe was suddenly filled with energy – hot and dense
- The **beginning** of spacetime, matter, and energy

The Big Bang

- No special points or locales
- Expansion of **all** space
- As spacetime expanded, the Universe became less dense and cooler
- Eventually forming the stars and galaxies we see today



http://www.atlasoftheuniverse.com/bigbang.html