Ralph Alpher, the Big Bang, and the Prize(s)

USU Physics Colloquium

September 4, 2007

Ralph Asher Alpher
passed away
on August 12, 2007
at the age of 86

He made two of the most important contributions to science in the 20th century

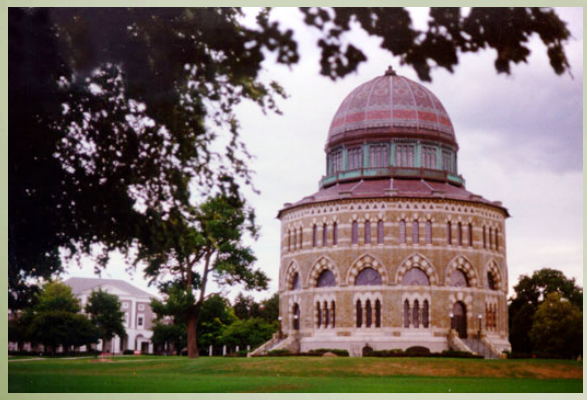
He was my long-time colleague and friend

Brief History of Alpher

- Eagle scout
- Graduated HS at 15
- Scholarship to MIT - withdrawn
- Work days, school at night at GWU
- During WWII worked at NRL, JHU
- Famous dissertation in 1948 under George Gamow
- Work on cosmology with Bob Herman in 1950s
- GE from 1955-1986

How I got to know Ralph

- Union College

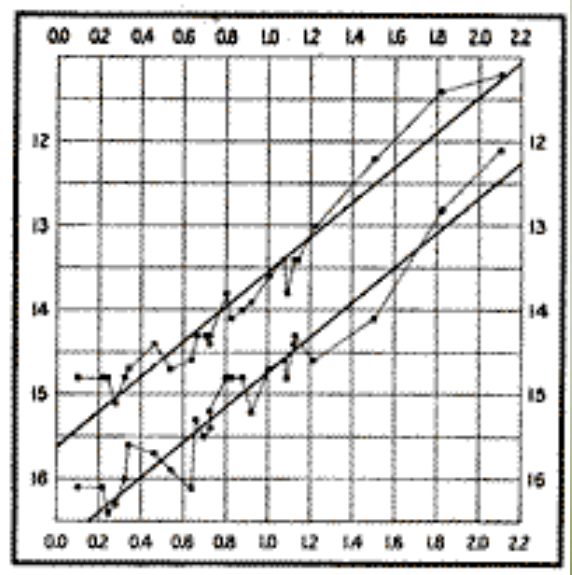


- Distinguished Research Professor of Physics, 1986-2004

What Ralph did:
he helped
"create
the (modern) universe"

The modern universe

- Henrietta Leavitt
  - Cepheid variables (1912)

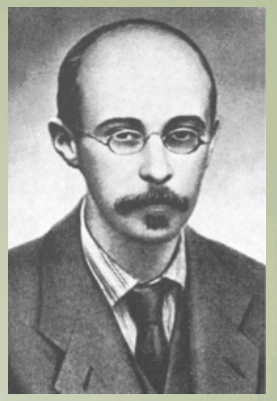


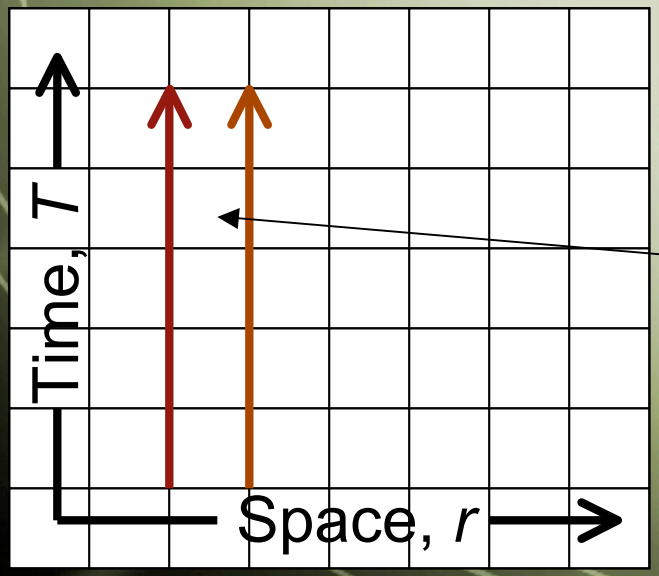
The modern universe

- Albert Einstein (1917)
  - The universe is the same everywhere and always has been (uniform and static)
  - A static universe isn't stable
  - Let there be stability: the **cosmological constant**

The modern universe

- Alexander Friedmann (1922)
  - Maybe the universe isn't static





Ex: $(d\tau)^2 = (dT)^2 - (a(T))^2(dr)^2$

$da/dT = \pm(8\pi G\rho/3c^2)^{1/2}a$

Two galaxies with constant Δr, aging, and getting farther apart (if $da/dT > 0$)

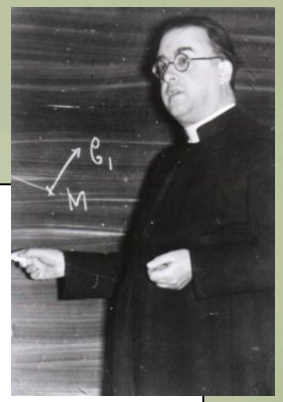
The modern universe

- Einstein (1924)

To Friedmann:

"Your math is OK, but there is no reality. The universe is static."

The modern universe



- Georges Lemaître (1927)
  - Unwittingly reinvented Friedmann
  - There is no need for a **cosmological constant**
  - The universe is expanding and has been since $a = 0$: " a day w/o a yesterday"

The modern universe

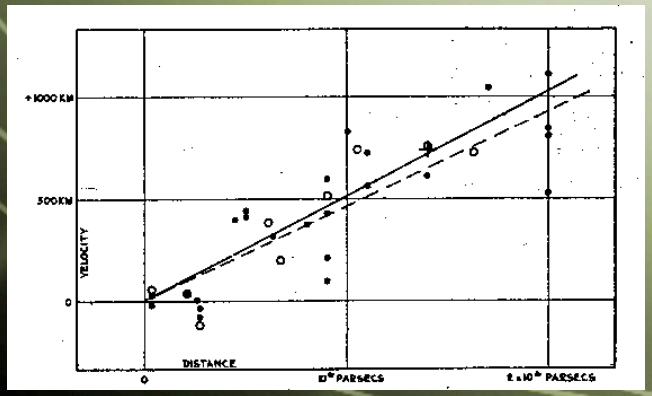
- Einstein (1927)

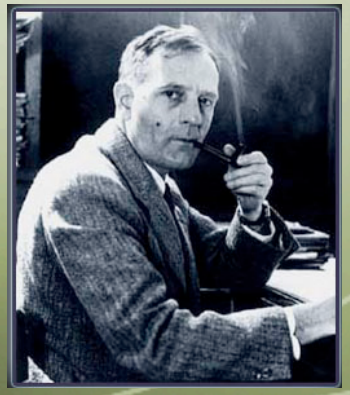
To Lemaître:

"I've heard this already from Friedmann. And, anyway, *your* physics is abominable! The universe is static!!"

The modern universe

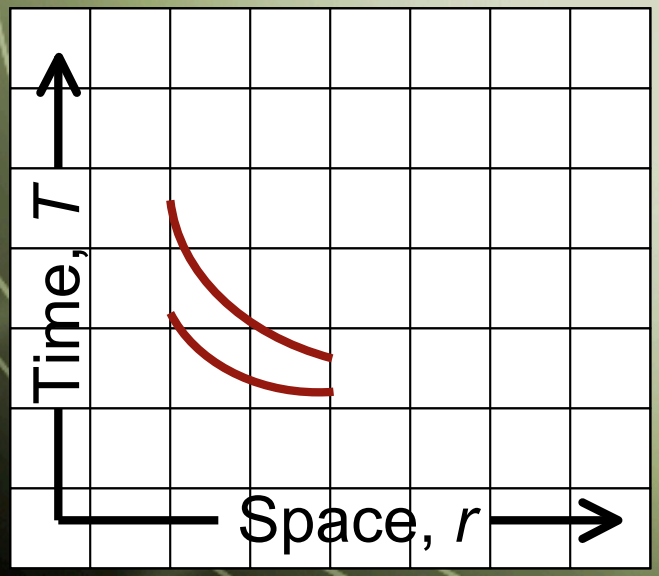
- Edwin Hubble
  - Other galaxies (1924) (Leavitt)
  - Light from distant galaxies is red-shifted (1929)
  - The universe might be expanding





The modern universe

- Friedmann-Lemaître actually predict the cosmic redshift



For light: $0 = (dT)^2 - (a(T))^2(dr)^2$

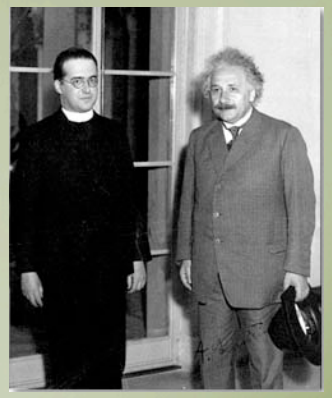
So, $dT/dr = \pm a$

The modern universe

- Einstein (1930)
  - "The **cosmological constant** was the biggest mistake of my life."

The modern universe

- Lemaître (1933)
  - The universe began when the "*primeval radioactive atom*" decayed



- Einstein (1933)
  - "This is the most beautiful and satisfactory explanation of creation to which I have ever listened."

The modern universe

- Lemaître (1935)
  - Problems with the age of the universe can be solved by using Einstein's **cosmological constant**
- Einstein (1935)
  - Oy vey!

The modern universe

- Arthur Eddington (1935)
  - Redshifts are “too slender a thread on which to hang such far-reaching conclusions”

The modern universe

- George Gamow (1946)
  - "I'll bet it was hot when a was small, maybe so hot you could fuse nuclei. Ralph, why don't you calculate that. (I can't.)"

1. The Constitution of Atomic Nuclei and Radioactivity (1931)
2. Structure of Atomic Nuclei and Nuclear Transformations (1937)
3. Mr. Tompkins in Wonderland (1940)
4. The Birth and Death of the Sun (1940)
5. The Biography of the Earth (1941)
6. Mr. Tompkins Explores the Atom (1945)
7. Atomic Energy in Cosmic and Human Life (1947)
8. One, Two, Three...Infinity (1947)
9. Theory of Atomic Nucleus and Nuclear Energy Sources (1949)
10. The Creation of the Universe (1952)
11. Mr. Tompkins Learns the Facts of Life (1953)
12. The Moon (1953)
13. Matter, Earth and Sky (1958)
14. Puzzle-Math (1958)
15. Physics: Foundations & Frontiers (1960)
16. The Atom and its Nucleus (1961)
17. Biography of Physics (1961)
18. Gravity (1962)
19. A Planet Called Earth (1963)
20. A Star Called the Sun (1964)
21. Thirty Years That Shook Physics: The Story of Quantum Theory (1966)
22. My World Line: An Informal Autobiography (1970) (posthumus)
23. Mr. Tompkins in Paperback (1965)
24. Mr. Tompkins Inside Himself (1967)

The modern universe

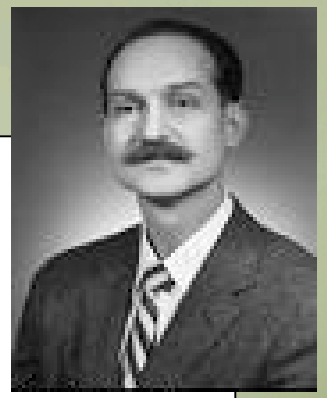
- Ralph Alpher (1948)
  - Window of opportunity for fusion
  - Over by 5 minutes after $a = 0$
  - Get 10 H for every He plus a little bit of other stuff (as observed)
  - The "α, β, γ" paper: Alpher, R. A., H. Bethe, and G. Gamow. "The Origin of Chemical Elements," *Physical Review*, **73** (1948), 803.
  - His PhD dissertation (300 in audience)

The modern universe

HERBLOCK Cartoon: "Five Minutes, Eh?"

The modern universe

- Alpher and Robert Herman (1948)



  - The universe should be suffused with relic blackbody radiation (CMB)
  - Current temperature should be ~5K
  - R. A. Alpher and R. C. Herman. "Evolution of the universe," *Nature* **162**, 774 (1948)

The modern universe

- Fred Hoyle (1950) The Big Bang
  - On BBC radio show:

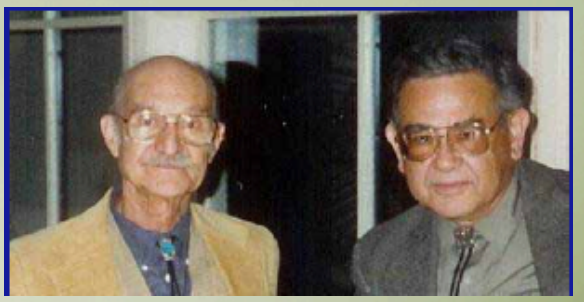
    "Now this Big Bang [*sarcastic tone*] idea seems to me to be unsatisfactory … it is an irrational process that cannot be described in scientific terms."

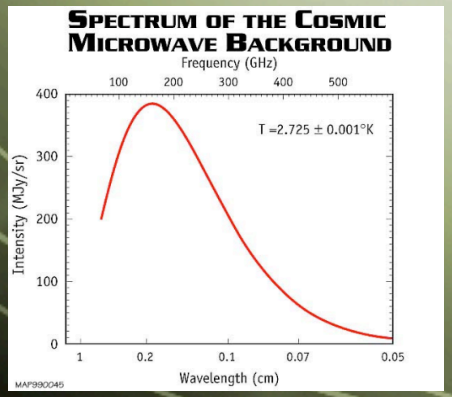
The modern universe

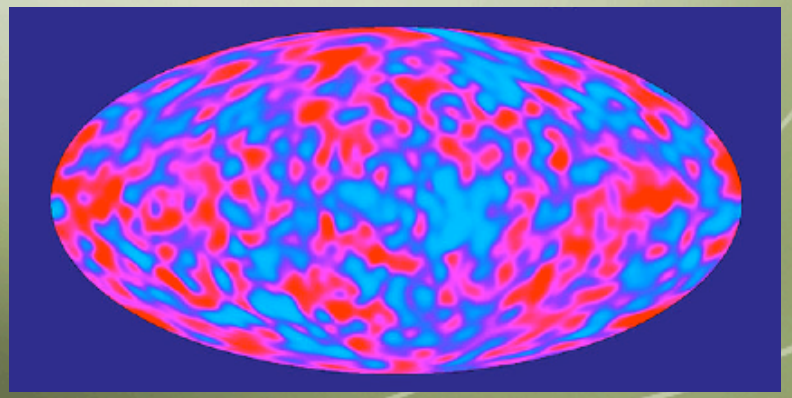
- Arno Penzias and Robert Wilson (1965)
  - Accidental discovery of the CMB
  - "They looked for dung but found gold, which is just opposite of the experience of most of us."

The modern universe

- COBE (1989) John Mather & George Smoot







The modern universe

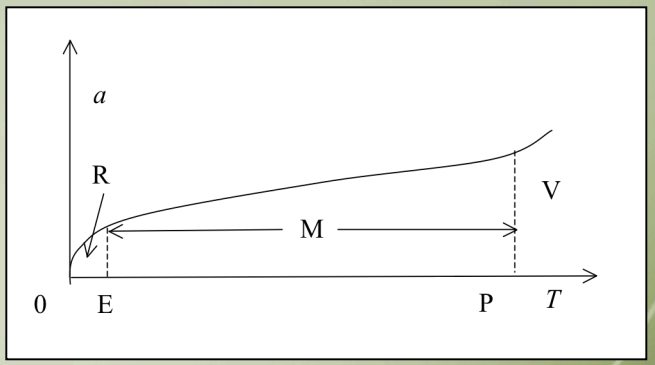
- Expansion is accelerating! (1998-)

Friedmann-Lemaître (again)

$$da/dT = (8\pi G\rho/3c^2)^{1/2}a$$

$$\rho = \rho_M + \rho_R + \rho_V$$

ρ_V acts like a **cosmological constant**! So, what's new?



Nobel Prizes for CMB

- 1978 Penzias & Wilson (shared with Pyotr Kapitsa)
- 2006 Mather & Smoot

Ralph was nominated several times

- Ilya Progogine (NP 1977)
- Hans Bethe (NP 1967) (also Wolf Prize)
- Robert Hofstadter (NP 1961) (and his son Douglas)

And did collect some recognition

- Magellanic Premium of the American Philosophical Society, 1975
- Georges Vanderlinden Physics Prixe of the Belgian Academy of Sciences
- John Wetherill Gold Medal of the Franklin Institute, 1980
- Henry Draper Medal, National Academy of Sciences, 1993 (every 4 years)
- October 2000, APS News, “Top Ten Astronomical Triumphs of the Last Millennium”

And most recently

- The National Medal of Science, July 27, 2007
  - "For his unprecedented work in the areas of nucleosynthesis, for the prediction that universe expansion leaves behind background radiation, and for providing the model for the Big Bang theory."

The History Channel

Tuesday, September 4, 2007 6-8 PM MDT

The Universe: Beyond the Big Bang

The universe began with a massive expansion, billions and billions of years ago, and it continues to expand with every passing second. The idea that the universe, and man's very existence, began with a "Big Bang" is no longer a topic of debate among most scientists--it is essentially taken as fact. How has man come to this conclusion, and how has our knowledge evolved so that we can recreate the very first seconds of our universe and all that has developed since? Interviews with the world's leading physicists and historians are woven together with animated recreations and first-person accounts to explain concepts such as the formation of galaxies, the creation of elements and the formation of Earth itself.

Includes interviews with Alpher.