National Aeronautics and Space Administration

Cosmic Times

1955

Late Edition

Age of the Universe:
6 Billion Years

Size of the Universe:
4-8 Billion Light Years

Death of a Genius

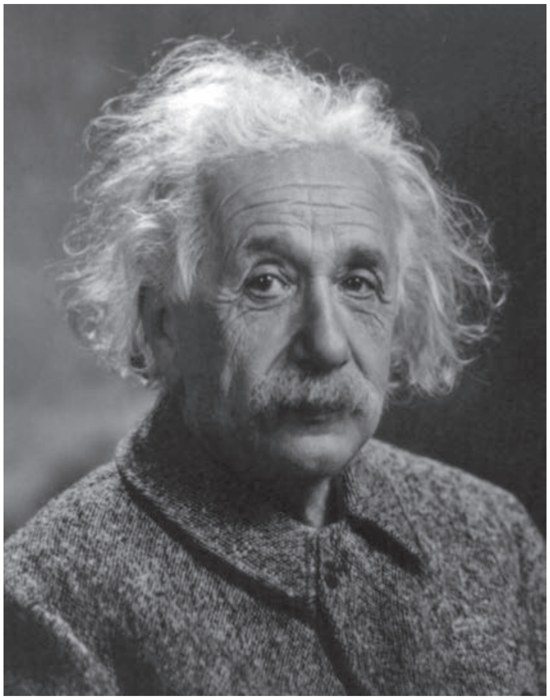

IMAGE CREDIT: ORREN JACK TURNER VIA THE LIBRARY OF CONGRESS

Albert Einstein

The world has just lost its greatest scientific mind. Albert Einstein died in his sleep on April 18th from complications of a lingering gall bladder infection. He was 76. There is no doubt that this rumpled, white-haired, pipe-smoking professor peered deeper into the nature of the universe than any other man. In death he joins a select few – such as Newton, Copernicus, Archimedes and Pythagoras – as a giant in science whose genius changed the course of history.

The immediate outpouring of tributes to the German-born scientist begins to convey his place in history. President Eisenhower said, "No other man contributed so much to the vast expansion of 20th century knowledge." Moshe Sharett, the Prime Minister of Israel observed, "The world has lost its foremost genius." There were even eulogies behind the Iron

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"Yardsticks" in Neighbor Galaxy Double Universe's Size

The universe is twice as large as we thought says Caltech astronomer Walter Baade, who has now employed the giant 200-inch glass reflecting telescope at Mount Palomar to confirm the scale of the cosmos.

Baade's discovery hasn't come from simply reading mile markers in space, of course. To properly divine the distance of stars and the scale of the universe, first he had to discover that Nature has created more than one kind of mile marker, or yardstick, if you will. Until a few years ago, there was just one cosmic yardstick known to astronomers, and it was being used incorrectly. Oddly enough, it took the wartime blackouts in Los Angeles to begin setting things straight.

That first universal yardstick was discovered around the turn of the century. It is a type of pulsating, variable star called a Cepheid. Henrietta S. Leavitt of the Harvard Observatory was surveying the Magellanic Clouds, those junior galaxies outside of the Milky Way, when she noticed that brighter Cepheids pulsed slower than dimmer Cepheids. This was intriguing, since for all practical purposes the stars in the Magellanic Clouds can be considered the same distance from Earth. It suggested that those Cepheids were offering up a handy relationship between their real (not just apparent) luminosity and their pulsation rate.

If, for example, an astronomer observes a fast-pulsating Cepheid in our own Milky Way galaxy which appears dim from Earth, he can use Miss Leavitt's brightness/pulsation relationship to surmise that the star is actually very bright, just very distant. Likewise, a slowly pulsing Cepheid which appears bright in our sky is probably a relatively dim star that only appears bright because it's closer.

The same relationship seemed to hold with Cepheids found in dense star clusters, in our own Galaxy, as was discovered by astronomer Solon Bailey. Finally, astronomer, Harlow

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Shapley standardized the yardstick so he could map the distance of fast-period and slow-period Cepheids both inside and outside globular clusters in the Milky Way.

"Thus a period-luminosity relation was established which covered the whole range of the Cepheid variation and which was accepted as the period-luminosity relation for the next 30 years," recalled Baade in a speech at a recent award ceremony of the Astronomical Society of the Pacific.

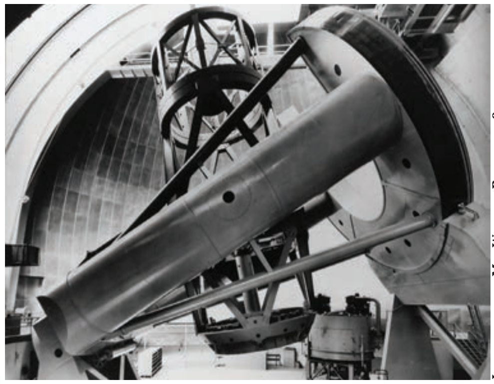

Image credit: Mt. Wilson–Palomar Observatories photo, courtesy AIP Emilio Segre Visual Archives, Physics Today Collection

The telescope that confirmed the scale of the cosmos: Mount Palomar's 200-inch Hale Telescope was completed in 1949.

Unfortunately, Shapley's yardstick had flaws, as the famous astronomer Edwin Hubble began to discover more than 20 years ago. Doctor Hubble began studying the starlight from globular clusters in the Andromeda nebula, a sister galaxy of the Milky Way, in 1931. For some reason those clusters were burning more dimly – 1.5 magnitudes dimmer – than their counterparts here in the Milky Way. This mismatch meant either the globular clusters in Andromeda are basically different animals than those in our own Milky Way, or Andromeda must be further than originally calculated.

As chance would have it, the solution came during the wartime blackouts of 1943 in California. Doctor Baade took advantage of the darkened skies and the power of the 100-inch Hooker telescope at the Mount Wilson Observatory near Los Angeles to re-examine Andromeda's globular clusters. Using special red-sensitive photographic plates Dr. Baade discovered two populations of stars: redder, fainter "Type II" stars near Andromeda's center and in its outlying halo (the same arrangement as in the Milky Way) and bluer, brighter "Type I" variable stars located in the outer spiral arms as well as in abundance in the Magellanic Clouds. So, Dr. Baade realized that there must be two populations of Cepheids – those Type I Cepheids more common in the disk of a galaxy and those Type II Cepheids more common in the globular clusters.

Each type of Cepheid, it turns out, has a different way of encoding its actual brightness into its pulsing light. It was as if the measuring stick for one type of Cepheid was measured in feet, i.e., a good old American yardstick, and the other was in cubits. The problem was Shapley had treated them both as regular 36-inch yardsticks.

"…[U]nknowingly Shapley had made a fatal step when he linked the cluster-type variables to the type I Cepheids through the type II Cepheids in globular clusters and that in reality were are dealing with two different period-luminosity relations," explained Dr. Baade.

Recently at Mount Palomar, Baade and his computer assistant Henrietta Swope confirmed that both types of Cepheids are very different stellar animals. After recalibrating his measuring sticks, Dr. Baade startled his peers in 1952 at the Rome meeting of the International Astronomical Union by announcing that Andromeda was not 800,000 light-years away, as Hubble thought, but 1.8 million light-years distant. Likewise, with the two measuring sticks sorted out, the universe we knew in 1929 to be one billion light-years wide has now doubled to two billion light-years across. ♦

It's a Star! It's a Nova! It's Super-Nova!

There's more than one sort of "new" star in the heavens, say astronomers. The evidence has been building for decades that novae – those stars which light up suddenly to great brightness, then fade away – actually come in at least two distinct classes. On one hand there are pedestrian, Clark Kent-like novae and on the other there are truly Super-Novae.

The first clue that there were super-novae lurking among the stars came 35 years ago by the recently deceased astronomer Edwin Hubble. Using his revolutionary method for measuring celestial distances, he calculated that a nova observed in 1885 in the Andromeda Galaxy actually must have been about one hundred times more luminous than any nova recently observed in our own Milky Way Galaxy.

Fourteen years later, in 1934, physicists Walter Baade and Fritz Zwicky coined the term "super-nova" when they suggested these were not only far brighter than normal nova, but rare, once-in-a-millennium, events in any given galaxy. The most recent super-novae in our own galaxy, they speculated, were those recorded by Germanic astronomer Johannes Kepler in 1604, and another seen by Danish astronomer Tycho Brahe in 1572.

A new wrinkle to the matter was added in 1941 by astronomer Rudolph Minkowski. He split the light from 14 distant galactic super-novae into their component colors and found that nine of these spectrums contained no telltale lines for hydrogen (Type I) and five did (Type II). The possible reason for this, speculates British cosmologist Fred Hoyle, is that in the superlative violence of their death throes, the giant stars that become supernovae might be capable of fusing hydrogen and helium to forge heavier elements like carbon and iron. They are then, truly, not only Super, but bona fide Stars of Steel. ♦

Origin of Everything:
Hot Bang or Ageless Universe?

It's difficult to imagine a deeper mystery than the one being addressed recently at the meeting of the National Academy of Sciences in Pasadena, California: Is the universe eternal or does it have a beginning, middle and an end?

The case for an ageless, steady-state universe which forever looks much as it does today was presented at the conference by astrophysicists Jesse L. Greenstein and physicist William A. Fowler of the California Institute of Technology. The steady state theory rivals the "evolutionary" theory of the universe which calls on an initial brew of hot particles exploding at the dawn of time and making all the universe's hydrogen and perhaps helium on one fell swoop.

Both theories explain – in entirely different ways – the inescapable fact that the universe is expanding. This cosmic expansion was first detected in 1914, when American astronomer Vesto Melvin Slipher surveyed some galaxies and noticed the light from most of them was "red-shifted." This is essentially the broadening and reddening of the visible light waves caused by the retreat of the galaxies. It's the electromagnetic equivalent of how the wail of a retreating locomotive drops in tone as it passes by a train watcher's ear.

In the steady-state theory the expansion comes from the continuous bubbling up of the most basic element, hydrogen, from empty space at a rate of one particle every cubic meter every 300,000 years or so. This hydrogen eventually gathers and condenses into stars which, through nuclear fusions in their cores, manufacture all the heavier elements. As stars age and die, they disperse the heavier elements around the galaxies, giving rise to new stars with rocky planets around them – like our own Solar System. As evidence of that process, Greenstein and Fowler referred to the heavy-element-making red giant stars which can be seen today in our Galaxy.

An important aspect of the steady-state is that it's anything but static, as the champion of this theory British cosmologist Fred Hoyle, likes to point out. Hoyle compares the deathless universe to a river. It may appear unchanging, but there is plenty of movement and change under the surface. So, to borrow the old river saying, you can never step into the same universe twice.

Then, on the other hand, there is the somewhat less rosy "evolutionary" theory of Russian-born American physicist George Gamow and his colleagues Ralph Alpher and Robert Herman. These scientists call on the explosion and decay of a hot ball of neutrons at the birth of the universe to create all the hydrogen and some helium. These elements froze out as

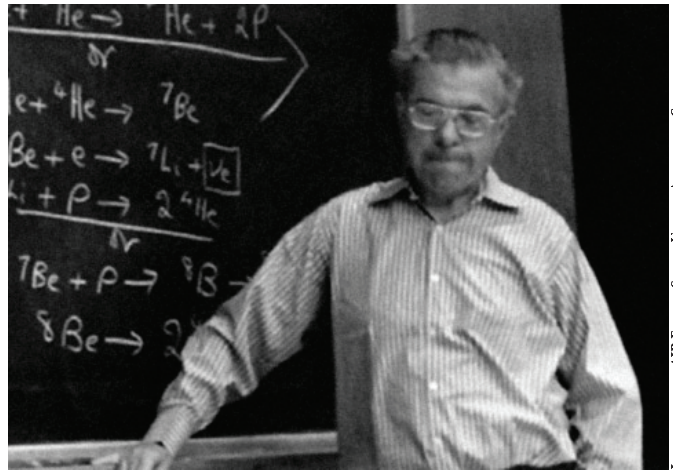

IMAGE CREDIT: AIP EMILIO SEGRE VISUAL ARCHIVES, CLAYTON COLLECTIONN

Fred Hoyle

the blast expanded and cooled. The first stars were made of only these original elements and fused them into new, heavier elements. These, then, were dispersed through the galaxies as the first stars died, and led to the less-pure mixtures of elements seen in stars now.

This evolutionary theory also accounts for the retreating galaxies: they are all still in flight from the power of the initial blast. There may be other direct evidence of the blast as well. Alpher and Herman have predicted that some faint residual heat from that initial explosion may still be glowing dimly in the form of stretched-out light waves, called "microwaves," just a few degrees above absolute zero. As yet, however, no one has devised a way to detect this theoretical remnant heat.

More accessible evidence for the evolutionary universe comes from Edwin Hubble's 1929 measurements of the velocities of galaxies beyond our own, which built on Slipher's earlier discoveries. Hubble found that the more distant in space a galaxy is, and therefore the closer in time to the original explosion, the faster they appear to be moving away from us. This is exactly what would be expected if there was an ancient blast that started it all and things have been slowing down ever since.

The downside to an evolutionary universe, of course, is that it doesn't end happily. There's no limitless fount of hydrogen as in the steady state theory. The universe has finite resources. So it might expand forever as all the stars burn out and the universe cools down to a vast, frigid stellar graveyard. Or the gravity of all matter might eventually pull everything back together again in an gigantic collapse that rebounds and starts the universe all over – the endlessly exploding and collapsing universe described by the late Caltech physicist Richard Tolman.

Which theory will prevail? Only more research with bigger and better telescopes will tell. ♦

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Curtain. *Pravda* described him as "A great transformer of natural science."

The true nature of Einstein's achievements are better known to his colleagues and scientific progeny, who still labor to understand, test and apply his theories. There is his revolutionary re-thinking of light as not just waves but particles. Then his theory of special relativity, which set speed limit within the universe at that of light. Or his most famous equation $E = mc^2$, which dissolved the wall between matter and energy. Finally, we have his space-time bending theory of gravitation. Taken together, Einstein's ideas are the basis of all modern physics.

For the non-physicist, however, Einstein's genius is a given, but largely a mystery. The man on the street knows that such things as television and the hydrogen bomb are the results of his work, but we scarcely grasps how it is so. We are, it seems, rather like the nurse at Einstein's deathbed, who failed to grasp the great man's final words, uttered in German. She did not speak German. Most of us do not speak physics. Instead, we sense the importance of the man indirectly and gaze like children at a parade, as his life and his genius passes before us. ♦

Hoyle Scoffs at "Big Bang" Universe Theory

British cosmologist Fred Hoyle has thrown down the gauntlet with regards to where and when all the universe's elements were created. In a recent radio broadcast he panned a rival theory, championed by Ukrainian-born American physicist George Gamow, labeling it a ridiculous "big bang."

Gamow's Evolutionary Theory of the universe calls on an initial stew of super-hot nuclear fusions of basic particles to create all the hydrogen in the cosmos in one explosive moment. The same blast then caused space to expand. The ongoing expansion from that "big bang" is observed by astronomers today throughout cosmos.

Hoyle is having none of it. "It is an irrational process that cannot be described in scientific terms … [nor] challenged by an appeal to observation," he has written regarding Gamow's theory.

For one thing, the "big bang" requires something before the explosion. No one knows what that might be. If on the other hand, the universe is eternal and stars are always being made and forever making heavier elements, as Hoyle suggests, there is no need for an initial explosion. Recent advances in nuclear physics seem to back Hoyle's "steady state" view, calling on the pressures and temperatures inside stars to manufacture all the heavy elements seen in the cosmos today. ♦

Radio 'Ear' on the Universe Being Built

IMAGE CREDIT: JODRELL BANK, UNIVERSITY OF MANCHESTER

Jodrell Bank's Mark 1 radio telescope under construction.

Construction continues for what will be Earth's largest steerable radio antenna for listening to celestial radio broadcasts. The huge, 250-foot-wide metal dish of the Mark 1 radio telescope at Jodrell Bank in England is designed to be a fully adjustable. This will allow astronomers to explore the entire sky for radio transmissions – something they cannot do today. It will also be able to investigate the recently discovered 1420.4 Megahertz radio emissions thought to be coming from hydrogen gas at the center of the Milky Way.

The MK1 will replace the 218-foot parabolic aerial antennae, also at Jodrell Bank. That pioneering aerial uses tall poles and wire mesh to reflect and concentrate radio waves to a single point. Though the current set up allows astronomers some leeway – they can tilt the 150-foot-high central receiver pole somewhat to cover a little more sky – it relies heavily on the spinning of Earth in its orbit to change its view of the heavens.

Despite that limitation, the eight-year-old parabolic aerial antenna has led to some important discoveries which more than made the case for building the Mark 1, according to its designer Dr. Bernard Lovell of the University of Manchester. Among the most startling discoveries were that there are radio emissions coming from the Great Andromeda Nebula and that the brightest radio emitter in the night sky is from a little nebula in the constellation Cassiopeia. ♦