# Origin of Everything: Hot Bang or Ageless Universe?

Has the Universe always existed, or does it have a beginning, middle and an end? It's difficult to imagine a deeper mystery than this. However, this topic was recently discussed at the meeting of the National Academy of Sciences in Pasadena, California.

The case for an ageless, steady-state Universe was presented at the conference by astrophysicist Jesse L. Greenstein and physicist William A. Fowler of the California Institute of Technology. The steady state theory says the Universe forever looks much like it does today; this "steady state" theory competes with the "evolutionary" theory of the Universe. The evolutionary theory claims an initial collection of hot particles exploded at the dawn of time. These particles formed all the Universe's hydrogen (and perhaps helium) in one gigantic event.

Both theories explain – in entirely different ways – the fact that the Universe is expanding. This expansion was first detected in 1914, when American astronomer Vesto Melvin Slipher surveyed some galaxies and noticed the light from all of them was "red-shifted." All light travels in waves. In the spectrum of visible light, red light has the longest wavelength. If an object (such as a galaxy) is giving off light and the object is moving away, that motion lengthens the wavelengths, causing the light to "red–shift". It's similar to how the sound of a retreating locomotive drops in pitch as it passes by you.

In the steady-state theory the expansion comes from the continuous bubbling up of the 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. Through nuclear fusions in their cores, stars make all the heavier elements (e.g. carbon, oxygen, silicon, iron, copper, etc.) from this hydrogen. As stars

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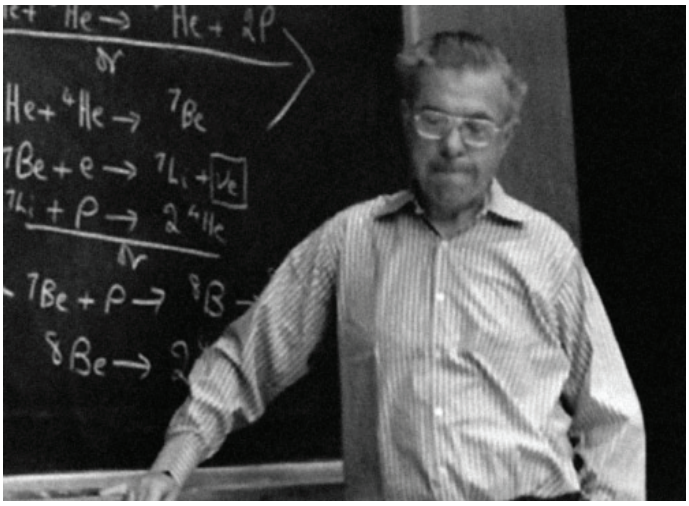
# Hoyle *Scoffs* at "Big Bang" Universe Theory

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 criticized a competing theory, presented by Ukrainian-born American physicist George Gamow. He labeled Gamow's theory as a ridiculous "big bang."

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

Hoyle strongly disagrees with this theory. "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. ♦



*Fred Hoyle*

*"Origin" continued from page 3*

age, die, and explode, they scatter the heavier elements around the galaxies. These heavier elements mix with hydrogen, and new stars form 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 own galaxy.

An important point of the steady-state Universe is that it does change over time. Hoyle, the scientist who supports this theory, compares the deathless steady-state 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.

In contrast, there is the "evolutionary" theory of Russian-born American physicist George Gamow and his colleagues Ralph Alpher and Robert Herman. These scientists say the explosion and radioactive decay of a hot ball of neutrons at the birth of the Universe created all hydrogen and some helium. These elements formed as the blast expanded and cooled. The first stars were made of only this original hydrogen and helium. Those stars fused those original elements into new, heavier elements. These heavier elements were then scattered through the galaxies as the first stars died, and this led to the more complex mixtures of elements seen in stars now.

This evolutionary theory also explains why galaxies are moving away from each other: they are all still in flight from the power of the initial blast. Newton's laws of motion help to explain this (an object in motion will remain in motion unless a force acts on it). There may be other direct evidence of the blast as well. Alpher and Herman have predicted that some faint left-over heat from that initial explosion may still exist in the form of stretched-out light waves called "microwaves" just a few degrees above absolute zero. However, no one has yet figured out a way to detect these left-over microwaves.

More evidence for the evolutionary Universe comes from Edwin Hubble's 1929 measurements of the speed of galaxies beyond our own. Hubble found that the farther away a galaxy is, the faster it appears to be moving away. This is exactly what would be expected if there was an ancient blast that started it all, and things have been moving away ever since.

The downside to an evolutionary Universe, of course, is that it doesn't end happily. There's no unlimited supply of hydrogen as in the steady state theory. In the evolutionary Universe, the Universe might expand forever and will eventually run out of hydrogen; the stars eventually burn out, and the Universe cools down to a vast frozen graveyard of dead stars. Another possibility for the evolutionary Universe is that the gravity of all matter might eventually pull everything back together again in a gigantic collapse that rebounds, explodes, and starts the Universe all over – this is the endlessly exploding and collapsing Universe described by the late physicist Richard Tolman from CalTech.

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

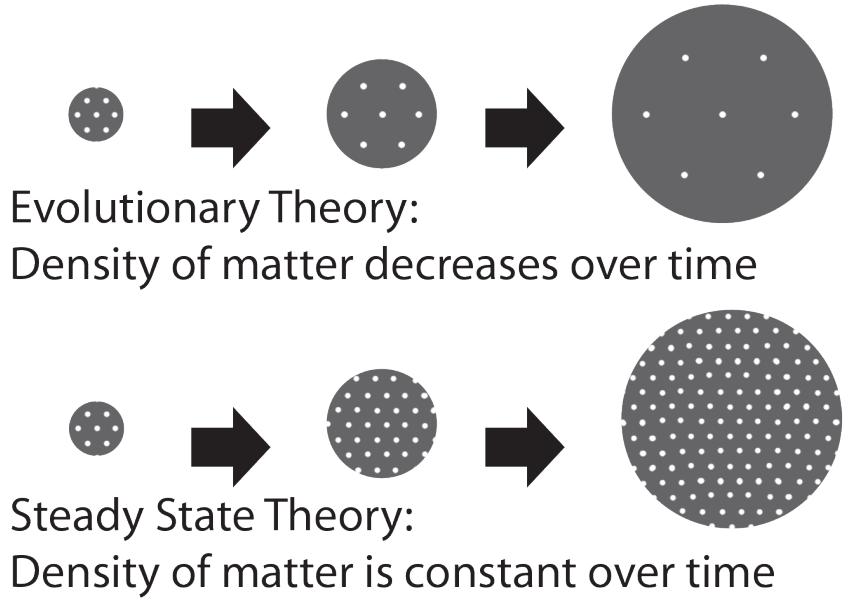



*Illustration of the matter-density history of the Universe according to the evolutionary theory (top) and the steady state theory (bottom).*

# 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 ordinary novae and on the other there are truly Super-Novae.

The first clue that super-novae were lurking among the stars came 35 years ago. This clue was found by Edwin Hubble who died recently. Using his revolutionary method for measuring distances in space, he calculated that a nova observed in 1885 in the Andromeda Galaxy actually must have been about one hundred times more luminous (that is, brighter) than any nova recently observed in our own Milky Way Galaxy.

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

A new observation was added in 1941 by astronomer Rudolph Minkowski. He split the light from 14 distant super-novae into their component colors and found that nine of these spectra contained no lines for hydrogen and five did. Super-novae without hydrogen lines are called Type I; super-novae with hydrogen lines are called Type II. The possible reason for this, speculates British astronomer Fred Hoyle, is that in the extreme energy of their "death", the giant stars that become supernovae might be capable of fusing hydrogen and helium to make heavier elements like carbon and iron. They are then not only Super, but actually Stars of Steel. ♦

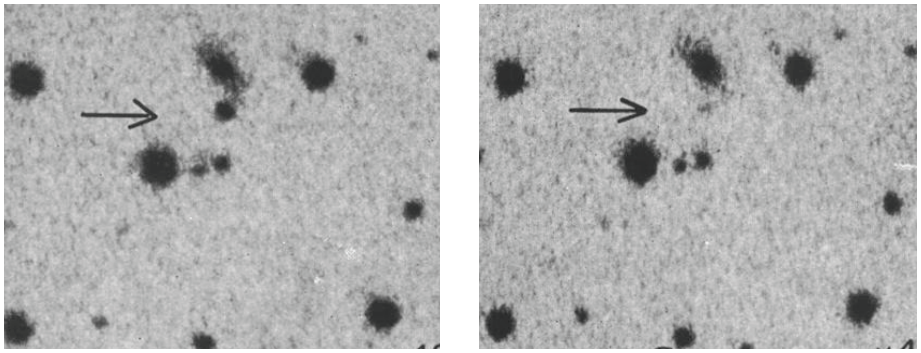


*Image showing a super-nova in a barred spiral galaxy a few days after peak brightness (left), and the same field two months later, when the super- nova had become much fainter. (Reprinted figure with permission from Zwicky, Reviews of Modern Physics, 12, 66, 1940. Copyright 1940 by the American Physical Society.)*

# Radio "Ear" on the Universe Being Built

Construction continues for what will be Earth's largest steerable radio antenna for studying radio waves from space.

*The Jodrell Bank's Mark I radio telescope being built. (Credit: Jodrell Bank, University of Manchester)*

The huge, 250-foot-wide metal dish of the Mark 1 radio telescope being built at Jodrell Bank in England is designed to be fully adjustable.

Astronomers have found that the sky glows not only in visible light, but also in radio waves. This telescope 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 an older antenna at Jodrell Bank that is only slightly adjustable – 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 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 was 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. ♦