1,5 Singularity Predictions of General Relativity

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The Big Bang Singularity

The Gamow Big Bang Theory

After astronomer Edwin Hubble discovered in 1929 that the universe is expanding, a number of scientists made the obvious assumption that the universe was created as an extremely dense mass that exploded billions of years ago. In 1947, this concept was strongly publicized by George Gamow, a nuclear physicist who had worked on the development of the atomic nuclear bomb. He was strongly opposed by Fred Hoyle who supported a competing "Steady-State" theory of the universe. In criticizing Gamow's concept, Hoyle derided Gamow's notion that the universe began with a "Big Bang". The name stuck, and after that Gamow's concept was called the Big Bang theory.

Recent data indicate that the rate of expansion of the universe is about 20 km/sec per million light years of galaxy distance. If we assume that the expansion is constant throughout the universe, a galaxy 15 billion light years away would recede at the speed of light (300,000 km/sec), and so cannot be seen. Hence 15 billion light years is generally considered to be the approximate radius of the "observable universe". If we extrapolate our simple model of the expanding universe backward in time, our universe seems to have been created as an extremely dense mass 15 billion years ago.

Gamow assumed that the universe was created as a body with the density of matter in the atomic nucleus, which is about 200 million metric tons per cubic centimeter, or one billion metric tons per teaspoon. ***Gamow considered this to represent the greatest possible density of matter.*** If we apply modern astronomical data to this Gamow postulate, our present observable universe would have begun as a spherical body with a circumference the size of the orbit of the planet Mars. This body, weighing one billion tons per teaspoon, presumably exploded with a "Big Bang" about 15 billion years ago, and has been expanding ever since, to produce the universe that we observe today.

Predictions Derived from General Relativity

When the General theory of Relativity was used to analyze the Big Bang, the studies indicated that our universe should have been created as a body with much, much, much greater density than Gamow postulated. The Einstein equations indicate that the initial universe should have been a "singularity" of essentially infinite density. Most astrophysicists now confidently claim that our universe was microscopic in size when it exploded with a Big Bang 13.7 billion years ago.

Although this singularity concept was calculated using Einstein's theory, ***Einstein absolutely rejected all singularities derived from his theory.*** In 1945, Einstein recognized that his theory implied a singularity at the birth of the universe, but he flatly rejected this interpretation of his theory with the following [5]:

> *"Theoretical doubts [concerning the creation of the universe] are based on the fact that [at the] beginning of the expansion, the metric becomes singular and the density becomes infinite. . . In reality, space will probably be of a uniform character, and the present [relativity] theory will be valid only as a limiting case. . .* ***One may not therefore assume the validity of the equations for very high density of field and of matter, and one may not conclude that the 'beginning of the expansion' must mean a singularity in the mathematical sense.*** *All we have to realize is that the equations may not be continued over such regions."* [Emphasis mine.]

In this quotation, Einstein stated that his theory could not be used to justify a physical singularity, because his equations would not apply accurately under conditions of extreme density of matter. The thinking of Albert Einstein on such issues is discussed in a recent biography of Einstein, originally written in German by Folsing [6], which states (p. 381):

> *"Some of Einstein's admirers were tempted to see the general theory of relativity as a triumph of speculation over empiricism. This kind of misunderstanding made Einstein 'downright angry' [who said] 'This development teaches us something entirely different, indeed almost the opposite, namely that a theory, in order to merit confidence, must be based on generalizeable facts'. . . . To Einstein, facts were not only the starting point of his theory but also the keynote of any test of it."*

Einstein had extensive experience with physical experiments, and was absolutely committed to the principle that theory must agree with physical evidence. ***Einstein's scientific philosophy is drastically violated when General Relativity is used to justify singularity predictions that grossly conflict with experimental evidence.***

The Black Hole Singularity

Astrophysical Research by Robert Oppenheimer.

J. Robert Oppenheimer was appointed technical director of the Manhattan nuclear atomic bomb project in 1942. Earlier, in 1939, he was a university professor engaged in astrophysical research. He studied the gravitational collapse of a star after its nuclear fuel is exhausted, and this research became the basis for the Black Hole concept.

The matter in a star experiences very strong gravitational pressure. In a normal star, this pressure is offset by pressure generated within the star by heat produced by nuclear fusion, in which two atoms of hydrogen are fused to form one atom of helium. Mass is reduced by 0.71 percent, and this reduction of mass (M) releases an enormous amount of energy (E) in accordance with Einstein's equation ($E = Mc^2$). When the hydrogen fuel is exhausted, the star collapses to produce a higher temperature, which allows another nuclear reaction to occur, in which three atoms of helium are fused to form one atom of carbon. This reduces the mass by another 0.065 percent. When all of the helium fuel is exhausted, gravitational pressure causes the star to collapse to form a white dwarf star, which finally shrinks to about the size of the earth. As the white dwarf collapses, gravitational energy is released, and the white dwarf glows white hot from gravitational energy. Eventually the white dwarf can shrink no more, and it cools to form a dark body called a black dwarf. In its final size, the white dwarf reaches a density of 2 tons per cubic centimeter, which is about one million times greater than the density of our sun today.

Under normal pressure, an atom consists of an extremely compact nucleus containing protons and neutrons, which is surrounded by a much larger cloud of electrons that rotate around the nucleus. When our sun runs out of nuclear fuel, nuclear reactions will have converted its hydrogen into helium and finally into carbon, and so the white dwarf star that it forms will consist primarily of carbon atoms. As the white dwarf collapses, the space occupied by the electrons shrinks. The diameter of a normal carbon atom is 100 times greater than that of a carbon atom in a black dwarf. Nevertheless, the diameter of a black-dwarf carbon atom is still 500 times greater than that of the atomic nucleus, which contains the protons and neutrons. There is still an enormous amount of space left within the atom that is occupied by electrons.

A star with more than 8 times the mass of our sun experiences a radically different fate when it runs out of nuclear fuel. Just as with lighter stars, hydrogen is converted into helium, which is converted into carbon. With the greater stellar mass, sufficient temperature and pressure is produced to form oxygen, neon, silicon, nickel, cobalt, and finally iron. The nuclear reactions from carbon to iron reduce mass by an additional 0.118 percent. Then nuclear fusion stops, because the formation of elements heavier than iron does not release energy; it absorbs energy.

When this massive star runs out of nuclear fuel, catastrophic gravitational collapse suddenly occurs. The gravitational pressure is so great that the electrons of every atom are forced into the protons to form neutrons. The electron cloud is eliminated, and so each atom shrinks to the size of its nucleus. Enormous gravitational energy is suddenly released, which causes the star to explode as a supernova that shines for a month with the brightness of billions of suns.

Part of the stellar material remains at the center of the supernova explosion, to form an extremely compact body called a neutron star, which consists entirely of tightly packed neutrons. A neutron star has the density of the atomic nucleus, which is about one billion tons per teaspoon. There is strong astronomical evidence that unbelievably compact neutron stars actually exist. They are observed as ***pulsars***, which emit pulses of electromagnetic radiation every time they rotate.

Oppenheimer and his graduate student George Volkoff presented the first analysis of the formation of a neutron star in a 1939 *Physical Review* paper titled, “On Massive Neutron Stars”. Oppenheimer wondered what would happen to a very massive neutron star. The Schwartzschild analysis of General Relativity has a theoretical limit, called the “Schwartzschild limit”, when the ratio of mass-to-radius of a star is 236,000 times greater than the ratio for our sun. When this limit is exceeded, the Schwartzschild analysis does not yield a solution. Oppenheimer believed that a neutron star could have sufficient mass to exceed this limit. What would happen to it?

A neutron star has a density of about 200 million metric tons per cubic centimeter (2.0×10^{14} gram/cm^3), which is 1.4×10^{14} times the density of our sun (1.4 gram/cm^3). The cube root of (1.4×10^{14}) is 52,000. Hence, if all of the mass of our sun were squeezed to form a neutron star, its radius would decrease by 52,000, and so the mass-to-radius ratio of this neutron star would be 52,000 times greater than the ratio for our sun. For constant density, mass is proportional to the cube of the radius. This indicates that the mass-to-radius ratio of a neutron star should be 52,000 times that of our sun, multiplied by $(M_n/M_s)^{2/3}$, where M_n is the mass of the neutron star, and M_s is the mass of our sun. If the neutron star has 9.7 times the mass of our sun, its mass-to-radius ratio should reach the Schwartzschild limit, which is 236,000 times the ratio for our sun. This issue is discussed further by this website in *Addendum* document *5,2 Schwartzschild and Isotropic Solutions of the Einstein Theory*, Section 2.

When a star collapses to form a neutron star, much of its mass is blown away in the supernova explosion, and so the neutron star has much less mass than that of the star that formed it. However some stars have 100 times the mass of our sun, and these probably yield neutron stars with at least 10 times the stellar mass. Besides, neutron stars have extremely high gravitational fields, and so they gain mass with time as they cannibalize other stars. Hence we would expect an appreciable number of neutron stars to exceed the Schwartzschild limit.

Oppenheimer and his graduate student Hartland Snyder applied General Relativity theory to a star with sufficient mass and density to exceed the Schwartzschild limit. The Schwartzschild analysis assumed that the size of the star stays constant with time. Oppenheimer and Snyder found that they could achieve a real solution from General Relativity when the Schwartzschild limit is exceeded by assuming that the diameter of the star decreases with time. They presented their analysis in a 1939 *Physical Review* paper, titled, "On Continual Gravitational Contraction" [7], which concluded with:

> *"When all thermonuclear sources of energy are exhausted, a sufficiently heavy star will collapse. Unless fission due to rotation, the radiation of mass, or the blowing off of mass by radiation, reduce the star's mass to the order of that of the sun, this contraction will continue indefinitely."*

This analysis concluded that when the Schwartzschild limit is exceeded, the star must collapse indefinitely until it reaches a singularity having an infinite density of matter.

The next month Einstein responded to this paper with an extensive analysis in *Annals of Mathematics* [8], but the Einstein paper politely did not specifically refer to the Oppenheimer-Snyder article. Einstein concluded with

> *"The essential result of this investigation is a clear understanding as to why the 'Schwartzschild singularities' do not exist in physical reality. Although the theory here treats clusters whose particles move along circular paths, it does not seem to be subject to reasonable doubt that more general cases will have analogous results. The 'Schwartzschild singularity' does not appear for the reason that matter cannot be concentrated arbitrarily. And this is due to the fact that otherwise the constituting particles would reach the velocity of light."*

A few years later, Oppenheimer became the manager of the Manhattan atomic bomb project, and never pursued this issue further. ***Neither did any other scientist while Einstein was alive.***

In his rebuttal of the Oppenheimer-Snyder paper, Einstein insisted that the ***singularity*** condition derived from General Relativity is non-physical. The proposition that a star could collapse indefinitely to form a ***singularity*** of infinite mass density severely violates our laws of physics. ***Einstein never accepted the physically impossible singularity***

The Black Hole Concept

Although this Oppenheimer-Snyder concept was not pursued officially by any scientist during Einstein's lifetime, it did not die. The theory indicates that such a collapsed star should be surrounded by a sphere, called the ***Event Horizon***, with a diameter equal to 6 km multiplied by the ratio of the mass of the collapsed star to the mass of our sun. Light cannot escape from inside the event horizon, and so the collapsed star became known as a ***Black Hole***. All of the mass inside the event horizon sphere is theoretically squeezed into a singularity of infinite density at the center of the sphere. The Black Hole became a popular theme in science fiction, and so the public became well aware of the concept. "Falling into a black hole" became a common science-fiction theme.

In the mid 1960's, a decade after Einstein's death, powerful computers became readily available, and scientists began to use them to solve the equations of General Relativity. One of the first of these was Stephen Hawking, who applied the Einstein gravitational field equation to analyze the Black Hole. Hawking showed that Oppenheimer and Snyder had been correct in their analysis of the Black Hole. Hawking found that Einstein's General Relativity equations definitely predict that a star with a mass-to-radius ratio exceeding the Schwartzschild limit must collapse to form a Black Hole singularity.

A little later, astronomers found strong evidence of massive stars that have mass-to-radius ratios that appreciably exceed the Schwartzschild limit. Scientists concluded that these stars must be Black Hole singularities, even though Einstein insisted that a singularity cannot exist. It has recently been reported that the centers of most galaxies, including our own Milky Way galaxy, contain massive Black Holes that may have the mass of a million suns.

Review of Einstein's Position on Singularitie*s*

Scientists believed that they had established the physical validity of the Black Hole singularity by proving that General Relativity theory requires a star with a mass-to-radius ratio exceeding the Schwartzschild limit to collapse indefinitely. However, in the 1945 quotation given above [5], Einstein acknowledged that his theory does not yield accurate results under conditions of extreme density of field and matter. ***According to Einstein, a singularity is physically impossible, and so any analysis based on General Relativity that predicts a singularity merely demonstrates a limitation in the General Relativity equations. It cannot prove that a singularity is physically real.***

Astronomers confidently claim that they have found numerous Black Holes. However, no one can actually see a Black Hole. What they are observing are extremely massive and dense stars that emit little radiation. Astronomers could be observing massive neutron stars having mass-to-radius ratios that greatly exceed the Schwartzschild limit. Since the equations of General Relativity predict that a neutron star with a mass-to-radius ratio exceeding the Schwartzschild limit must collapse to form a Black Hole, ***these astronomers insist that they must be observing Black Holes***.

However, Einstein knew that a Black Hole is physically impossible, because all of the mass of a Black Hole is theoretically concentrated into a singularity at its center, having a mass-density that is essentially infinite. Einstein acknowledged that a singularity solution calculated from General Relativity merely shows that his equations are not accurate under extreme density of matter. ***A physically impossible prediction of any physical theory can only mean that the theory is deficient; it cannot be used to prove that the prediction is physically real.*** Einstein's scientific philosophy was absolutely committed to this principle.

A neutron star has an extremely high density of matter, one billion tons per teaspoon. This density may seem unbelievable, but it is still physically possible. That same density exists here on earth within the nucleus of every atom. The Gamow Big Bang theory postulated that the universe began as a single body having the density of "nuclear matter", or in other words it had the density of a neutron star. The "observable universe" is usually considered to extend to 15 billion light years. If we assume that all of the matter within this "observable universe" is compressed within a spherical body with the density of a neutron star, this body would just fit within the orbit of the planet Mars. According to Gamow's theory, this would have been the size of the universe at the instant of the Big Bang, because nuclear matter has the maximum possible density of matter.

Modern Big Bang theorists use General Relativity theory to "prove" that the universe was created as a singularity at the instant of the Big Bang. Their estimates of the initial size of the "observable universe" vary from "the size of a dime" down to "smaller than a proton". Gamow based his Big Bang postulate on physical evidence, which predicts an observable universe compressed to the size of the orbit of Mars. Modern Big Bang theorists base their physically impossible singularity predictions solely on the Einstein gravitational field equation. Yet the Einstein gravitational field equation was merely a guess by Einstein; it was not derived rigorously.

For nearly a half century, countless scientists have used this Einstein postulate to support a multitude of speculative concepts that contradict physical evidence, and are often physically impossible. These include the Big Bang singularity, the Black Hole singularity, "dark matter" that is radically different from normal matter, "dark energy", a physically impossible explanation for the quasar, "parallel universes", "worm holes", the string-theory concept that matter consists of infinitesimal strings vibrating in 11 independent dimensions, etc. These scientists claim that they are following in Einstein's footsteps. They often claim that Einstein's brilliant reasoning had initiated their science-fiction speculations, but nothing could be further from the truth.

Throughout his lifetime, Einstein insisted that physical theory must agree with observational evidence. Admittedly, Einstein's relativity concepts may seem unbelievable, but they were all based on sound physical logic that was developed to explain observational evidence that appeared to be contradictory. ***Einstein's theories were not based on speculation.***

Much of astrophysical science today is not physics; it is metaphysics. Our modern picture of astronomy is drastically distorted by science-fiction speculations, while our technically sophisticated instruments are amassing a wealth of scientific astronomical data.

Singularities and the Yilmaz Theory

The Yilmaz gravitational theory does not predict any singularities. It does not have a “Schwartzschild limit”, and does not predict a Black Hole. There is no limit to the allowable mass of a neutron star. Since a very massive neutron star would exhibit an extremely high redshift, at least some quasars might be massive neutron stars that are much closer than their redshifts indicate.

References

[5] Albert Einstein, *The Meaning of Relativity*, Princeton University Press, 5th ed., 1953, ISBN 0-691-02352-2, (1st ed. 1921), (*See* appendix for 2nd ed., 1945, p. 129).

[6] Albrecht Folsing, *Albert Einstein, a Biography*, 1997, (transl. from German by Ewald Osers). Penguin Books, NY, ISBN 0-14-02.3719-4.

[7] J. R. Oppenheimer and H. Snyder, "On Continued Gravitational Contraction", *Physical Review*, Sept. 1939, vol 56, pp 455-459.

[8] Albert Einstein, "On a stationary system with spherical symmetry consisting of many gravitating masses", *Annals of Mathematics*, Oct. 1939, vol 40, No 4, pp 922-936 (see p. 936).