The Big Bounce Overtakes the Big Bang

A playful child bounces a ball as he walks; the ball constantly changes trajectory as well as height. This simple concept is the brainchild behind Martin Bojowald's theory describing the distances traveled by walking as time, and the ball itself as the universe. Bojowald's theory in quantum physics stems from the works of famed physicists such as Stephen Hawking, Roger Penrose, and Albert Einstein. All of the scientists have worked endlessly attempting to discover the key to unlocking the secrets of the origin and motion of the universe. The Big Bang theory resulted from Einstein's work in the early twentieth century and attempted to answer questions regarding the universe. As technology and methodology progressed over time, many scientists discovered the problems created by the Big Bang and sought a more accurate solution. Thus, the Big Bounce theory was conjectured to fit modern quantum mechanical equations to describe the origin and motion of the universe through the concept of cycles. Although many physicists still believe fully in the Big Bang, the Big Bounce theory offers a far clearer explanation of the universe.

The Origin and Function of the Big Bang:

The Big Bang originated as an application of Einstein's classical theory of general relativity. The classical theory describes the geometric relationship between space-time and energy through extensive and detailed equations, including the universally known $E=mc^2$. The equations suggest a lack of true physical definition and the inability of gravity to retain stability as it fluctuates in relation to space and time. The general theory of relativity held many uses, but the most famed was applied to the creation of the universe; as a result, the Big Bang was founded in 1922 by Alexander Friedmann. The Russian mathematician applied several of Einstein's equations and conceived a point of singularity to the origination of the universe. Friedmann measured that within the point, lay an infinitely high density, temperature, and energy, causing the point to gradually expand, as shown in Figure 1. As the volume of the universe increased, the temperature inversely decreased, cooling at a high rate (Lightman). According to Kenneth Chang, researchers have observed the galaxies on the periphery of the universe and established a time period of 13.73 billion years since the

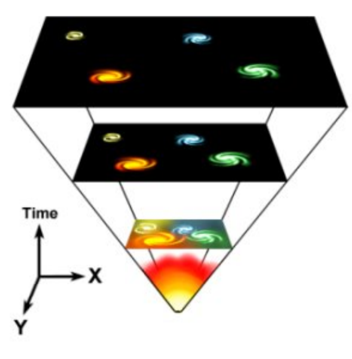

Figure 1: The universe expands after the Big Bang at the point of singularity.

conception of the universe. As the universe continues its expansion, the density correspondingly decreases from the infinite point and causes the attractive force of gravity to become weaker and weaker. In fact, Jon Matson states that dark energy contributes to the expansion, acting as a repulsive force—gravity's opposition. Dark Energy is the material that takes up roughly 70% of the universe, and most of its characteristics are unknown to researchers. It fills up a large portion of the empty space in the universe and acts as an accelerant to the expanding universe.

Problems with the Big Bang:

Although the Big Bang appears to answer the question regarding the beginning of the universe, many issues arise as a result. The theoretical concept of the Big Bang is unfathomable to many scientists because of the seeming contradiction that the universe originated from a mass-less singular point yet contained an infinite amount of energy, temperature and density. With the Big Bang occurring approximately 13.73 billion years ago, the initiation of the expansion was questioned as well as the origin of the universe's matter. Additionally, the theory of the Big Bang lacks an answer regarding a plausible end to universe. The inability to discover the validity of a finite point prevents researchers from progression into the structure of the universe ("Before the Beginning").

Additionally, Abhay Ashtekar states that besides the theoretical perplexities issued by the Big Bang, the mathematical fallacy prevents further calculations into the cosmic makeup of the universe. Within the theory of the Big Bang there did not reside a time period prior to the point of expansion; thus, the point of singularity was situated on the time spectrum at the value of zero. Bojowald notes that in order to investigate the Big Bang, the point of singularity had to be the focal point of the analysis. As a result, researchers were forced to use zero as the time value in the quantum mechanical equations describing the universe. However, with the time value existing as zero, a void was created within the equations causing them to become useless. The equations work perfectly at any positive non-zero time point, but for an equation to be held true every possible value must gain success. The fact that the most important value—the singularity point—cannot be demonstrated proves that in order to depict the creation of the universe, a new theory or idea must be discovered ("Loop Quantum Cosmology"). This new idea came to be known as the Big Bounce theory.

Function and Description of Big Bounce Theory:

The Big Bounce theory relies on the idea that the universe was not simply created at a singular point, but rather that the universe travels in cycles. Coincidentally, according to Joseph Brean, the religion of Hinduism relies heavily on the concept of travel through cycles—reincarnation, time, and the universe. However, the many researchers contributing to the developing quantum theory clearly exhibit that the theology and the science are pure happenstance. The theory that the universe is thought to follow is known as Loop Quantum Gravity or LQG. This theory was conjectured by Professor Martin Bojowald of Penn State when he attempted to tackle the Big Bang. He discovered a hybrid between Einstein's classical theory of general relativity and modern quantum equations. The result concluded in the Hamiltonian constraint equation, shown in Figure 2, to depict the universe through the course of a wave-like travel. The many components of the equation rely on the idea that the universe mimics a wave in its movement (Ashtekar).

$$\frac{\partial^2 \Psi}{\partial \phi^2} = C^+(v)\Psi(v+4,\phi) + C^o(v)\Psi(v,\phi) + C^-(v)\Psi(v-4,\phi)$$

Figure 2: The Hamiltonian constraint equation in its entirety.

Bojowald notes that in the beginning of a cycle, the universe appears to expand following the same principal as the Big Bang. Again, the gravity's attractive force was reversed by the dark energy, causing repulsion within the system. Eventually, the lack of total energy, density and temperature causes the universe to reach its apex of expansion. At this position, the universe would be at its largest by volume as well as its lowest in temperature. From the apex, the universe begins to condense. Confluence occurs because the densities of the galaxies are increasing; thus, gravity is then applied as an attraction force between galaxies and as they begin to come together, the universe reduces in volume. As a result of the decrease in volume, the temperature inversely increases, attempting to reach the point of infinite heat ("Following"). The density of the universe as a whole continues to increase reaching epic proportions, as shown in Figure 3. However without the possibility of attaining the infinite density described in the Big Bang, the density

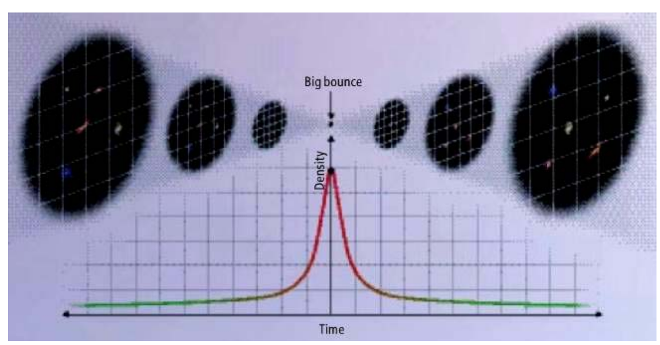

Figure 3: The density reaches its apex before experiencing the Big Bounce

climaxes before a limit. When the density reaches the limit, the universe experiences a "crunch" and is ushered into the next universe. Plank's Limit of $4.6x10^{113}$ joules per meter squared serves as a transporting bridge between two separate universes. The density concentration represents the extent the density can reach before it begins to decrease. With the density decreasing in the new universe, the volume of the system begins to expand, and the cycle repeats itself. Density, volume, and temperature all lie on an ever changing continuum as the cycle of a new universe begins (Ashtekar).

Possible Discrepancies and the future of the Big Bounce Theory:

The theory is still under development and is generally discussed with a caveat because of disagreement over the shape of the second universe. Bojowald argues that the universe expands sporadically, and that each universe retains a unique shape. He states that the extrapolation of the shape cannot be determined with the current equations and theory. He adds that in the near future the shape could grow apart from what is theorized ("Loop Quantum Cosmology"). However, physicists Parampreet Singh and Alejandro Corichi determined that the universe is completely symmetrical in every aspect and that the universes prior to this one followed the same path as the current one (Zyga). Because of the motion of the universe, the laws of physics still apply and energy will be theoretically conserved across the bounce. The properties of the current universe, 13.73 billion years after the latest crunch would exhibit the same properties of the universe 13.73 billion years prior to the bounce. Despite the differences among visions of the next cycle, all of the researchers concur that the theory has a unlimited amount of potential and that several lingering holes and questions will be answered in the near future.

Conclusion:

As a result of the problems associated with the Big Bang, the newly hailed Big Bounce Theory offers an alternate vision into the composition of the universe. Although some components of the new theory are undiscovered, the future appears promising in the establishment of the Big Bounce as a universally accepted theory. In a field of extensive change, the Big Bounce theory will be a constant over time.

References:

Ashtekar, Abhay. "Quantum Nature of the Big Band in Loop Quantum Cosmology." Institute for Gravitational Physics and Geometry. 6 Mar. 2006. Physics Department, Penn State. 21 Nov. 2008 <http://igc.psu.edu/outreach/articles/solvaynet.pdf>.

"Before the Beginning: The Big Bang Theory Challenged." Weblog post. The Daily Galaxy: News from Planet Earth & Beyond. 7 Aug. 2007. 18 Nov. 2008 <http://www.dailygalaxy.com/my_weblog?2007/08/before-the-begi.html>.

Bojowald, Martin. "Following the Bouncing Universe." Scientific American Oct. 2008: 44-51.

Bojowald, Martin. "Loop Quantum Cosmology." Living Reviews in Relativity (2008) Abstract. 14 Nov. 2008 <http://relativity.livingreviews.org/Articles/lrr-2008-4/>.

Brean, Joseph. "The Big Bounce vs. the Big Bang." National Post [Toronto] 3 Oct. 2008. 17 Nov. 2008 <http://www.nationalpost.com/story.html?id=859062>.

Chang, Kenneth. "Gauging Age of Universe Becomes More Precise." New York Times 8 Mar. 2008. 11 Dec. 2008 <http://www.nytimes.com/2008/03/09/science/space/09cosmos.html?_r=2>.

Lightman, Alan. "Relativity and the Cosmos." Nova. PBS. 9 Dec. 2008<http://www.pbs.org/wgbh/nova/einstein/relativity/>.

Matson, Jon. “New Theories May Shed Light on Dark Matter.” Scientific American 10 Nov. 2008. 16 Nov. 2008 <http://www.sciam.com/article.cfm?id=new-theories-dark-matter>.

Zyga, Lisa. "Before the Big Bang: A Twin Universe?" Physorg. 9 Apr. 2008. 22 Nov. <http://www.physorg.com/news126955971.html>.

Images:

Ashtekar, Abhay. "Quantum Nature of the Big Band in Loop Quantum Cosmology." Institute for Gravitational Physics and Geometry. 6 Mar. 2006. Physics Department, Penn State. 21 Nov. 2008 <http://igc.psu.edu/outreach/articles/solvaynet.pdf>.

"Big Bang Model." Cartoon. Pus Magazine. 28 Dec. 2008 <http://plus.maths.org/latestnews/may-aug07/prebigbang/bigbang.jpg>.

"Replacing the Bang." Cartoon. Scientific American Oct. 2008: 50.