The Nobel Prize in Physics of 2011 was awarded jointly to Saul Perlmutter, Adam G. Riess, and Brian P. Schmidt for the discovery of the universe's accelerating expansion due to observations of distant supernovae. Perlmutter received half of the prize while both Riess and Schmidt received one- fourth. Born in 1959, Champaign-Urbana, IL, USA, Saul Perlmutter worked in the Lawrence Berkeley National Laboratory in Berkeley, CA at the University of California, Berkeley during the time period in which conducted his work that earned him the Nobel Prize. Brian P. Schmidt, born in 1967, Missoula, MT, USA, was affiliated with the Australian National University in Weston Creek, Australia, during the course of his Nobel work, and Adam G. Riess, born 16 December 1969, Washington, DC, USA, worked at Johns Hopkins University in the Space Telescope Science Institute. Saul Perlmutter headed the Supernova Cosmology Project which began in 1988 while Brian Schmidt headed the High-z Supernova Search Team initiated in 1994, in which Adam Riess was a prominent member, both of which were searching for distant supernovae. The efforts of such investigations were to discover the speed that the supernovae were moving away from our galaxy and their relative distance away from Earth in an attempt to explain the expansion of the universe. The teams expected to find a periodic relationship that the expansion of the universe was slowing down as seen via a slower acceleration in distant supernovae, yet what they discovered was the opposite- the expansion of the universe was accelerating.

Pulsating stars called Cepheids, which had previously been studied by American astronomer Henrietta Swan Leavitt, were used to determine the distance of faraway supernovae. Based on the intrinsic brightness of a Cepheid, its relative distance could be calculated based on its position to another Cepheid, and hence the distance of the supernovae both research teams were studying could be determined utilizing the Cepheid principle applied to supernovae. Due in

large part to the technological revolution in the 1990s that brought about more sophisticated telescopes on the ground and in space, more powerful computers, and Nobel Laureates Boyle and Smith's work in developing charged- coupled devices in 2009, the conditions were present for the competing research teams to observe exploding white dwarfs far beyond the normal range of study. After grueling efforts and numerous potential pitfalls, both research teams were reassured that they had produced the same counterintuitive results: that some 50 supernovae studied had emitted weaker light than expected. If the universe's expansion had been accelerating at a slower rate, than the supernovae should have appeared brighter, and yet they were darker, as if more distance than before now separated them from our galaxy. Therefore, the logical conclusion followed that the universe's expansion was not slowing down, but rather it was accelerating at a faster rate. Now the problem that confronts physics is what is causing such acceleration in expansion, and how it is doing it. Coined "dark energy," the force that causes the universe's increasing expansion has raised several theories of its origin, one even reviving Einstein's self-rejected concept of a cosmological constant, yet none of which have found basis in research.

The idea of the expansion of the universe of course did not begin with Saul Perlmutter, Adam G. Riess, and Brian P. Schmidt. In the 1920's Slipher, Wirtz, Lundmark, Lemaitre, and Hubble discovered that the universe was not contracting due to the attractive force of gravity, but rather the universe was expanding. This discovery also implies the existence of dark matter and vacuum energy (dark energy) due to the fact that if the entire universe was made of matter than the laws of gravitation would apply. Einstein's theories of General Reletivity and Special relativity also helped pave the way for the discoveries made by Perlmutter, Riess, and Schmidt. Hubble's Law that a galaxy's distance is proportional to its radial recession velocity also helped

prove background a framework for the work that won the 2011 Nobel Prize in Physics. It should also be noted that Lemaitre achieved similar results 2 years before Hubble did, his work was not translated into English by that time however, although he is credited for the idea that lead to the concept of the big bang- that the Universe must have existed for a finite time only due its nature of expansion and this some event must have triggered the universe's existence and its expansion.[1]

The Supernova Cosmology Project (SCP) co-founded by Perlmutter and Pennypacker was based at Berkeley Lab and established that Type Ia supernovae could be used to measure the rate of expansion of the universe. The research systematized a process that had previously seemed too hard for data collection regarding supernovae. "In retrospect it seems obvious, but we realized that the whole process could be systematized," Perlmutter explains. "By searching the same group of galaxies three weeks apart, we could find supernovae candidates that had appeared in the meantime. We could guarantee four to eight supernovae each time, and all of them would be on the way up" growing brighter instead of already fading. Type Ia supernovae are regarded as some of the brightest, known objects in the universe, and they are ideal for study because they have levels of brightness that can be standardized to less than 10 percent, and thus used to determine distance and how far back in time it exploded. When the results of the research were published, Perlmutter said "The chain of analysis was long, and the Universe can be devious, so at first we were reluctant to believe our result, but the more we analyzed it, the more it wouldn't go away."[2]

[1] "The Nobel Prize in Physics 2011". Nobelprize.org. 25 Jan 2012 http://www.nobelprize.org/nobel_prizes/physics/laureates/2011/

[2] Preuss, Paul. United States. U.S. Department of Energy. *Evolving Search for the Nature of Dark Energy*. 2009. Web. <http://newscenter.lbl.gov/feature-stories/2009/10/27/evolving-dark-energy/>.

Meanwhile the competing research team, the High-z Team, was the first to publish evidence that the expansion of the universe is accelerating. In a 1998 study led by Adam Reiss of the Space Telescope Science Institute and supervised by team leader Brian P. Schmidt of the Mount Stromlo Observatory, part of the Australian National University, the supernovae were discovered and charted that lead to the theory of an accelerating universe, the existence of dark matter and energies, and won the Nobel Prize.[3]

In conclusion, the work of the two research teams lead by those who received the Nobel Prize in Physics in 2011 discovered that the universe is expanding with acceleration which implies the existence of dark matter and dark energies that compose 74% of the universe. The work was fueled by the technological advances made during the late 1900's most notably powerful telescopes for retrieving data and advanced computers for processing data. The results of the research teams were expedited due to competition between research teams rather than outside factors such as government involvement and war. Thanks to the contributions of scientists in the 1920's that discovered that the universe was expanding as well as Einstein's theories of relativity, the scientists were equipped with the correct paradigm to achieve these Nobel Prize winning results. These results opened a new frontier for research in modern physics- the existence of dark matter, dark energies, and other factors that may have led to the universe's accelerating expansion. From an educational standpoint, these men's work has forever altered mankind's paradigm of the world, galaxy, and universe in which we live in, or perceive that we live in. The findings of these Nobel Laureates revealed that the universe is 95% unknown to science, and like in old times, everything is possible again.

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[3] Schmidt, Brian. "Cosmology of Supernovae." *The High-Z SN Search* . Harvard, n.d. Web. 23 Jan 2012. <http://www.cfa.harvard.edu/supernova/home.html>.

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