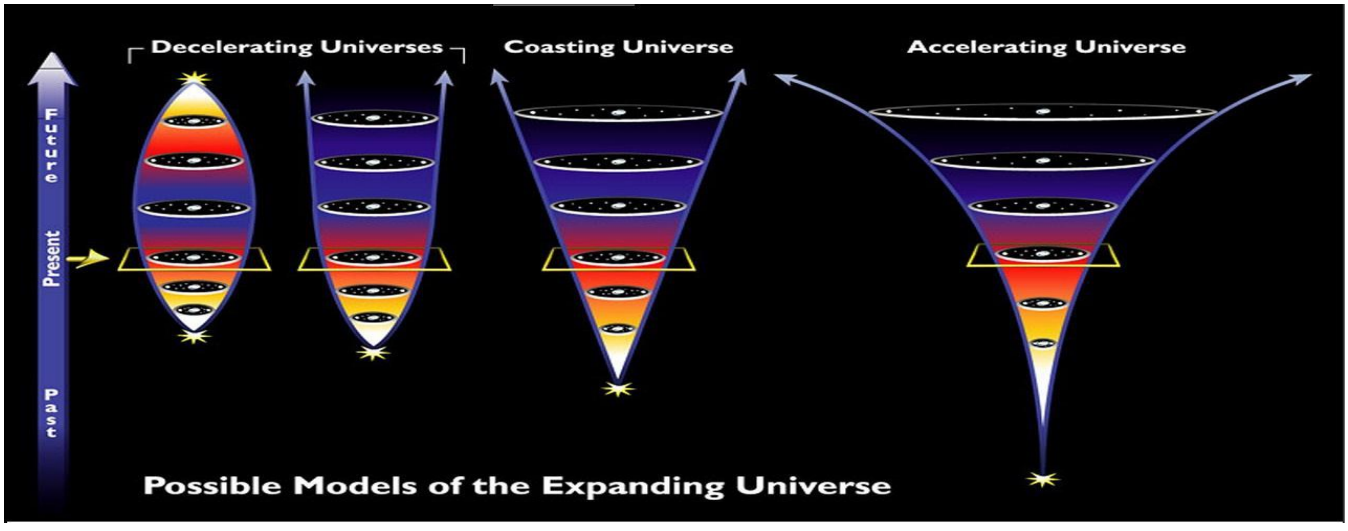
Scientific Article

The Expanding Universe and the Enigma of Dark Energy

N. Navin Bappalige[1] , S. Arjun Rao[2], A. Jayarama[1] and Richard Pinto[2]
[1]Physics Dept., Sahyadri College of Engineering & Management, Adyar, Mangalore-575007
[2]E & C Dept., Sahyadri College of Engineering & Management, Adyar, Mangalore-575007.
Email: navin.phy@sahyadri.edu.in

For thousands of years our species has looked at the night sky and wondered with fascinating curiosity. Recently we celebrated the 400th anniversary of Galileo's vital contribution in the form of a path breaking instrument to look at the heavens, the telescope. However, Universe and its existence are much more complex than what we see through the telescope. As we all know, the law of gravity which operates in astronomical distances and timescales is the fundamental force in the universe. Einstein rst proposed a `cosmological constant' as a mathematical x to the theory of general relativity. In its simplest form, general relativity predicted that the universe must either expand or contract. Einstein conjectured that the uni-verse was static; to overcome the gravitational collapse he proposed a counter-force in the form of `cosmological con-stant' to `stabilize' the universe. Friedmann, (a Russian mathematician) however, thought that this was an unsta-ble x, and proposed an expanding universe model, which was later validated by the fantastic discovery of Doppler shift in Galaxies in 1927 by Edwin Hubble which showed that the universe is indeed, expanding. To explain the ori-gin of the expanding universe, cosmologists came up with a `Big Bang' theory which postulates a nite expanding universe that has not existed forever, and that all mat-ter, energy and space in the universe was once squeezed into an innitesimally small volume, which erupted in a cataclysmic `explosion' . and viewed the cosmological constant term as his `greatest mistake' .

When the expansion theory was accepted, two scenar-ios were possible: Universe might have su-cient energy density to stop its expansion and possibly re-collapse, (because the Universe is full of matter and the attractive force of gravity pulls all matter together); or it might have so little energy density that it would never stop expanding. However, the new observation in 1998 with Hubble Space Telescope created further complexity: the very distant supernovae, a few billion light years away, indicated that the Universe then was actually expanding more slowly than it is today; this opened up a window on mysterious dark energy, which lead to 2011 Nobel Prize in physics for three researchers (Saul Perlmutter, Brian P. Schmidt and Adam G. Riess) whose discovery helped to unveil a Universe that to a large extent is unknown to science. In other words, the expansion of the Universe has not been slowing due to gravity, but accelerating due to a mysterious force. This introduced a new complexity which none expected. In order to explain the observed phenomena, cosmologists conjectured two possible explanations. First, a long-discarded version of Einstein's theory of gravity which contained the `cosmological constant' ; and the second, some kind of eld that creates this cosmic acceleration which is called dark energy.



This innitely dense and innitely hot gravitational singularity occurred some 13.7 billion years ago, though estimates vary between 11 and 18 billion years. It is interesting that after the Big Bang theory was adopted by cosmologists, Einstein regretted modifying his elegant theory

Shown above are three possible models of expanding universe: at extreme left is the decelerating universe which reaches current size with a least amount time. In the absence of any other eld deceleration occurs due to gravity which could eventually contract and collapse into a big

crunch. A coasting universe shown at the center is older than a decelerating universe because it takes more time to reach its present size; unlike the previous case this expands forever. At extreme right is the expanding universe with a nite acceleration indicated by 1998 supernova observation. The rate of expansion (acceleration) increases due to repulsive force caused by the dark energy.

If the acceleration is to be driven by dark energy, then dark energy itself remains an enigma - perhaps one of the greatest in physics today. What is known is that dark energy constitutes about three quarters of the Universe, i.e almost 68% of the Universe as per the present postulates; the dark matter makes up about 27%. The rest - everything ever observed with all our instruments, all normal matter - adds up to less than 5% of the Universe!!.

References

[1] https://www.spacetelescope.org/images/opo9919k/.