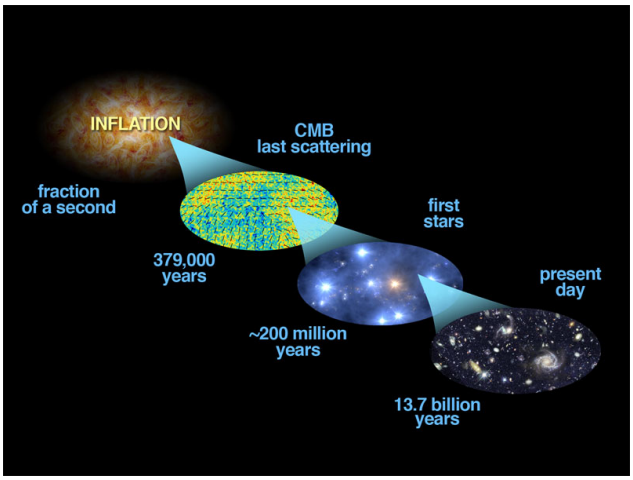
THE UNIVERSITY OF CHICAGO

Compton Lectures Fall 2014
Shining light on the Dark Side of the Universe

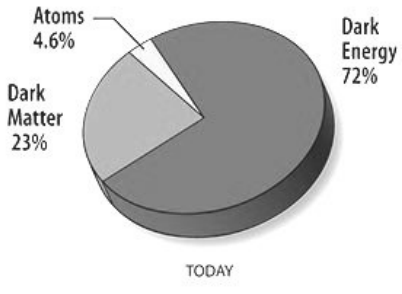
What is Dark Energy?

Elise Jennings

The expansion of the Universe is being accelerated by a mysterious force but apart from giving it a name we really don't know much about Dark Energy! Two key properties distinguish it from normal matter in the Universe - it doesn't clump together like matter and it acts like a negative pressure or repulsive force of gravity on large scales. These bizarre properties may actually be explained by looking at a quantum vacuum - an equally bizarre place. In Quantum Field Theory the vacuum is never empty and is teeming with virtual particles whose existence is fleeting. The presence of these virtual particles would represent a "Cosmological Constant" of energy in the Universe which has exactly the same properties as Dark Energy.



In this lecture we will examine the Cosmological Constant and the mysteries surrounding the density of Dark Energy in the Universe today.



The discovery that the expansion of the Universe is being accelerated by a mysterious force that cosmologists call "Dark Energy" has had an immense impact and is the most exciting area of research in Cosmology today. The 2011 Nobel Prize in physics was awarded to three astronomers, Adam Riess, Saul Perlmutter and Brian Schmidt, who found the first direct evidence of this acceleration by observing the brightness of exploding stars in the Universe. These astonishing observations have ignited a race towards an even bigger discovery – what is Dark Energy? In this lecture we will examine the evidence that the

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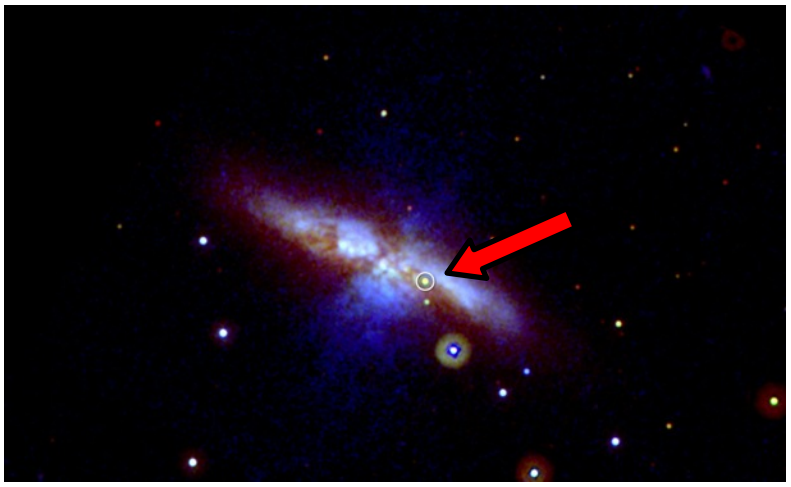
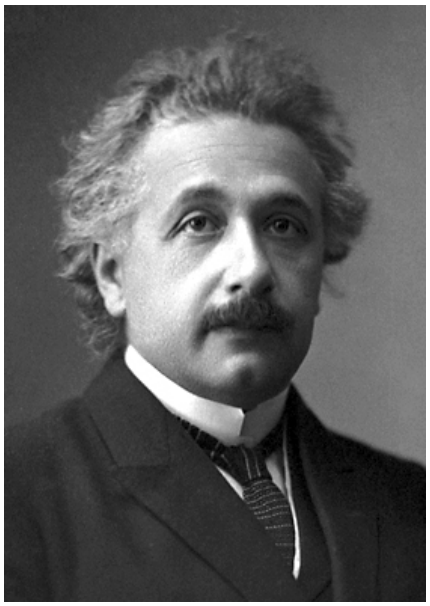
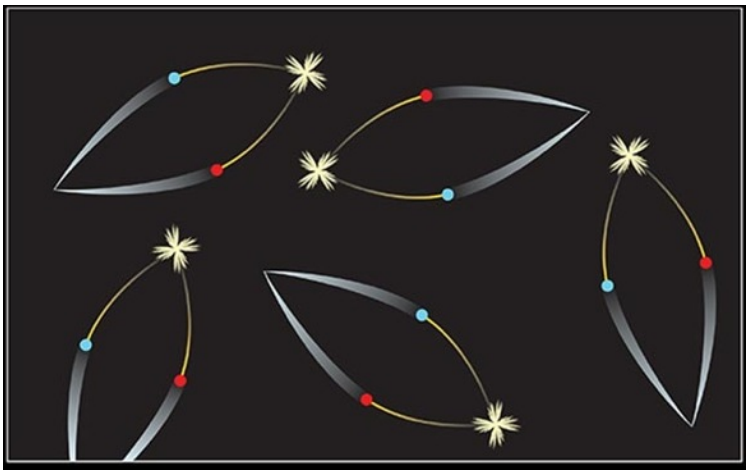


Universe is expanding ever more rapidly. The first conclusive observational evidence for Dark Energy came from measuring the distances to type Ia Supernovae. In 1998 two teams of astronomers used different analysis techniques and different supernovae samples and both came to the same conclusion - that the expansion of the Universe is actually speeding up. Supernovae remain an important probe of cosmology as they have known luminosities and can be considered as "standard candles" when building a cosmic distance ladder. The image above shows the very recent supernovae in M82 ("The Cigar galaxy") detected by Nasa's Swift satellite. The image on the left is from 2013 while the image on the right is from January 2014





Although we have firm observational evidence that dark energy exists, to date we still don't know what it is! One possible explanation, which we will discuss in this lecture, is Einstein's famous cosmological constant which arises from quantum mechanical phenomena called virtual particles.

http://chasm.uchicago.edu/compton.html