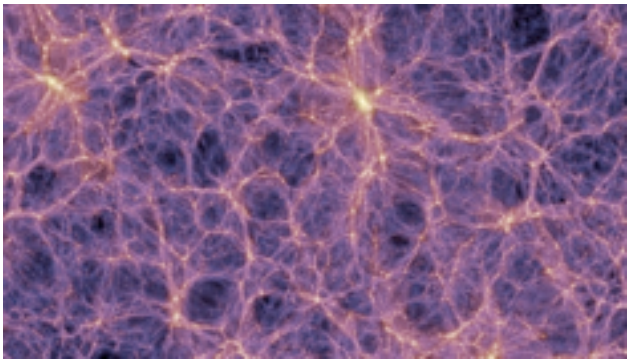
THE UNIVERSITY OF CHICAGO

Shining Light on the Dark Side of the Universe

Did you know? - All the objects we see around us - people, buildings, the Earth - are composed of matter. But observations tell us that this "visible" matter makes up only 5% of the universe's total mass. The rest of the universe is dark, and doesn't interact with light at all. Scientists have found two primary components of the dark side of our universe: dark matter, and dark energy.

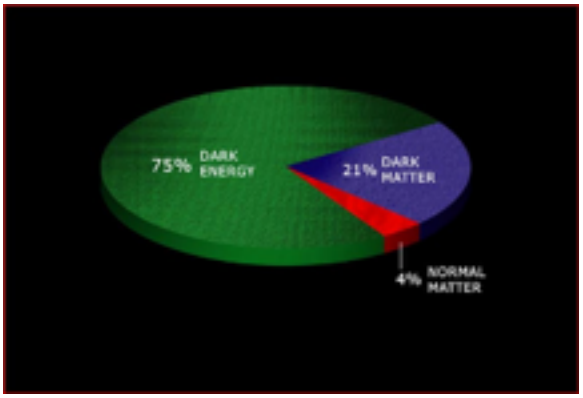
What is Dark Matter? - *An undetected particle!* A much larger portion of the universe's mass is composed of "dark matter". The large mass of dark matter has a profound effect on how the universe has evolved around us. However, due to the fact that dark matter does not interact with light, we have not yet seen a dark matter particle.



This "spider-web" shows how dark matter is distributed throughout our universe. Galaxies are formed along the bright regions where there is lots of dark matter. The brightest locations in this image are massive galaxy clusters containing thousands of galaxies!

How do we know that Dark Matter Exists? - Stars orbiting around our galaxy are "lasso-ed" by the gravitational pull of all the other mass in the galaxy. Observations found that stars near the outskirts of our galaxies moved much faster than if they were only pulled by the mass of observable stars and gas Therefore, scientists predict that another, unseen, mass must be pulling stars around galaxies.

What is Dark Energy? - *We don't quite know….* Most of the energy density of the universe (~72.8%) is composed of a nearly homogeneous, very low density field, called dark energy. The density of dark energy is very low (the total amount of dark energy in the Earth is less than 1/1000th of a gram). This field may be a property of *space itself* — while the density of "visible" matter and dark matter both decrease as space expands, the density of dark energy appears to stay constant. However, alternative theories are being proposed and tested in order to understand this strange phenomena of our universe.



Observations of the Cosmic Microwave background, emitted when our universe was very young - indicate that the universe is approximately 72.8% dark energy, 22.7% dark matter, and 4.5% normal "visible" matter.

How Do We Observe the Dark Side of the Universe? - *The search is on!* Interestingly, we study dark matter and dark energy by examining their effect on the visible matter that we can see with telescopes and other experiments. That's right! We primarily search for the dark side of the universe using light.

So understanding the properties of light, how it works and how we can detect it, is critical to understanding the mysteries of our dark universe. In this lecture, we will first discuss how light works, and what light can tell us about the history of the universe. We will then discuss how we can design sensitive experiments that use the properties of light to unravel the mysteries of the dark side of our universe.