National Aeronautics and Space Administration

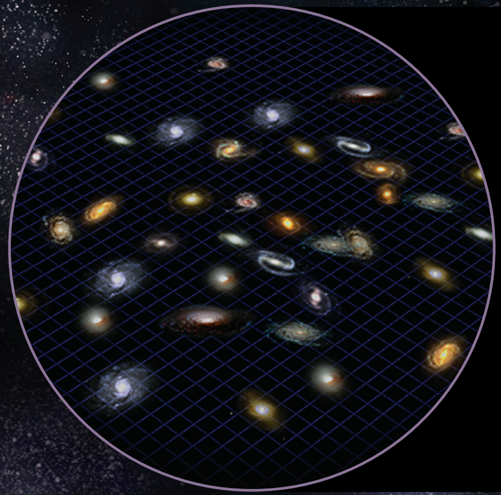
The Universe

Presented by NASA's Chandra X-ray Observatory

Like the jelly beans in this jar, the Universe is mostly dark: about 96 percent consists of dark energy (about 73%) and dark matter (about 22%). Only about 4.6 percent (the same proportion as the lighter colored jelly beans) of the Universe—including the stars, planets and us—is made of familiar atomic matter. X-rays can help reveal the secrets of the darkness. X-ray astrophysics is crucial to our understanding not only of the Universe we see, but the quest to determine the physics of everything.

Dark Universe

The two largest pieces of the Universe, dark matter and dark energy, are the two that we know the least about, yet nothing less than the ultimate fate of the Universe will be determined by them. Dark matter tends to pull the Universe together, and dark energy tends to drive it apart. A full understanding of this cosmic struggle will require major observational and theoretical breakthroughs.

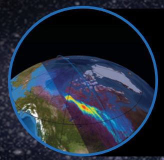


Dark Energy

At the close of the 20th century, our perception of the Universe was jolted. Instead of slowing down after the Big Bang, the expansion of the Universe was found to be accelerating. Was the cosmic acceleration due to Einstein's cosmological constant, a mysterious form of "dark energy," or perhaps a lack of understanding of gravity? The answer is still out there. By studying clusters of galaxies, X-ray astronomy is tackling this question using powerful techniques that are independent of other methods currently being employed or proposed for the future.

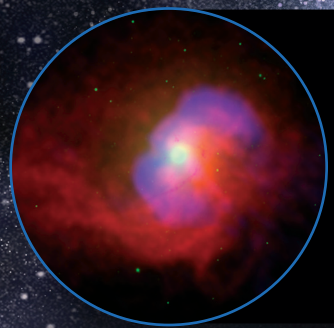
Dark Matter

The next largest chunk of the Universe's budget is another unknown: dark matter. Of all of the material we know about because we can see its gravitational effects, about 85% is composed of matter that emits no light and is radically different from material found in planets and stars. X-rays can be used to study the effects of dark matter in a variety of astronomical settings, and thus probe the nature of this mysterious substance that pervades the Universe.



Observable Cosmos

The remaining 4% of the Universe is composed of everything we can see with our eyes and telescopes. This includes all intergalactic and interstellar gas and dust, stars, planets, and life. Before dark matter was discovered in the 1930s, this 4% was our entire Universe. Scientists now use their telescopes and computers to learn ever more about the exciting objects and phenomena in the observable cosmos, but also to glimpse through keyholes into the much larger Dark Universe.

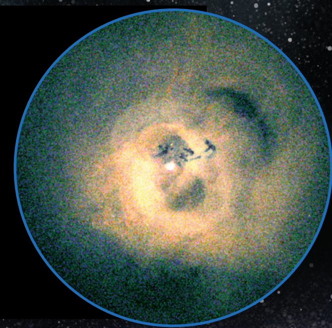


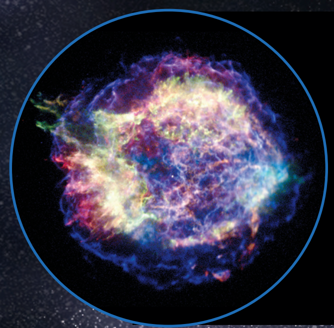
Black Holes

Black holes – once the subject of science fiction – are now science fact. X-ray telescopes have been crucial in this shift of thinking. While many things have been learned about these mysterious objects, much more remains to be discovered. In fact, black holes provide a natural arena for quantum mechanics and general relativity to meet and clash. This means that if we are ever to unify the theories of physics (the much sought-after goal of the physics of everything), we need to push forward the studies of black holes.

Galaxy Clusters

Galaxy clusters are the largest structures in the Universe that are held together by gravity. These mammoth objects can contain thousands of individual galaxies, are immersed in vast clouds of hot gas, and are held together by immense amounts of dark matter. The hot gas, which radiates at temperatures detectable by X-ray satellites like Chandra, contains much more mass than the galaxies themselves. Their size and mass, along with their rich reserves of dark matter, make galaxy clusters valuable cosmic laboratories for the study of the properties of the whole Universe.



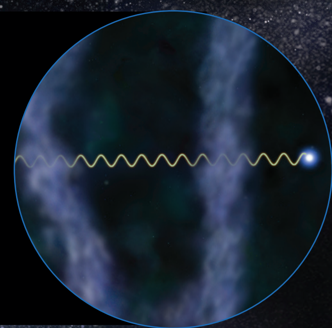


Supernovas

Supernovas are produced when stars end their lives in spectacular explosions so bright that they outshine their home galaxies. During their lives, stars convert hydrogen and helium into heavier, more complex elements, which are distributed into space when the star explodes. Nearly everything on Earth, including life, owes its start to the demise of earlier generations of stars that went supernova. The remnants of supernovas can glow in X-ray light for thousands of years, and reveal their secrets to sensitive X-ray telescopes.

Missing Baryons

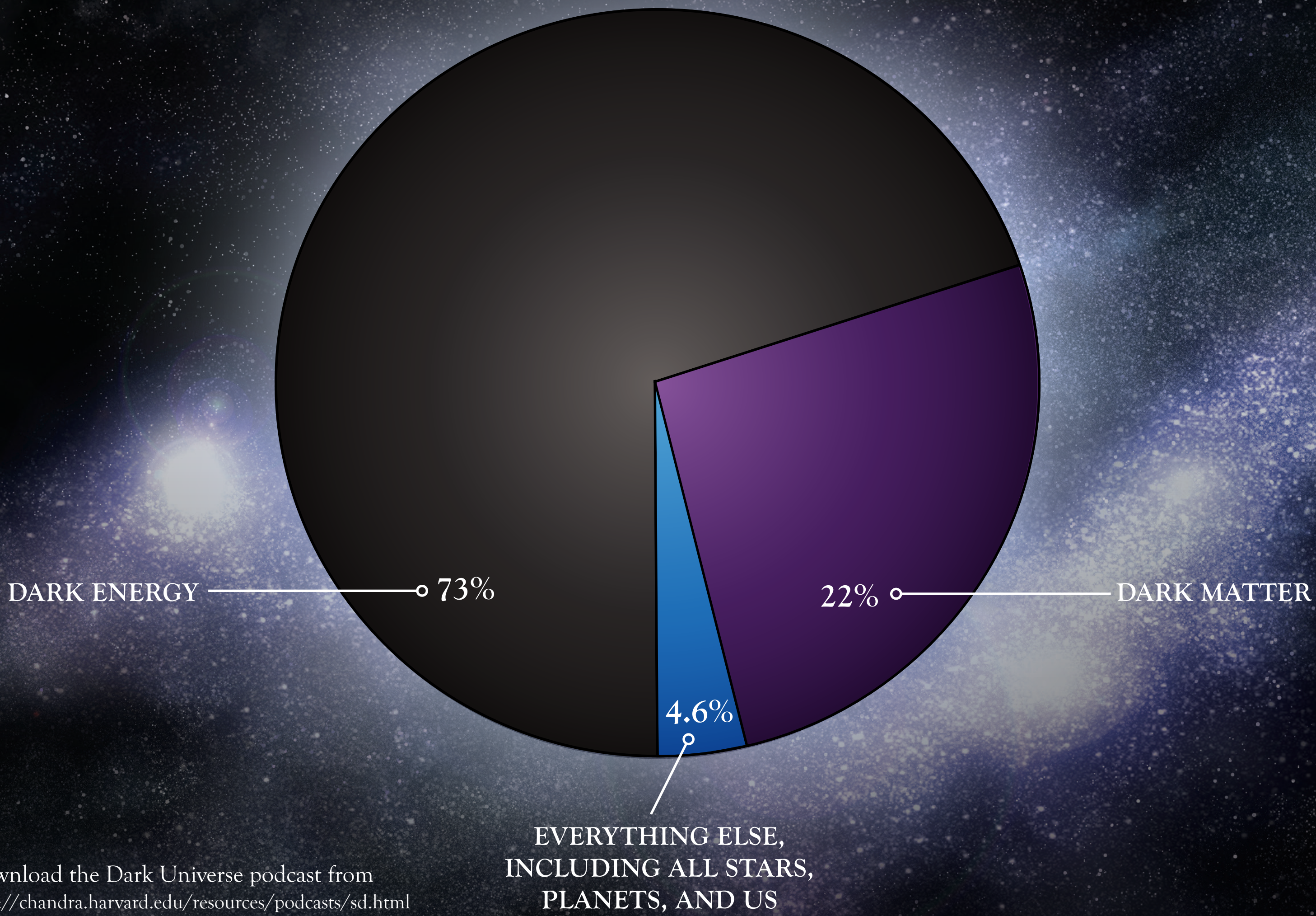
Astronomers have known for some time that about half of all of the baryonic matter, a.k.a. protons and neutrons, in the recent, nearby Universe is unaccounted for. It's all there in the early Universe, so where did it go? One idea is that these missing baryons became part of an extremely diffuse web-like system of gas clouds from which galaxies and clusters of galaxies formed. One of the best ways to detect these missing baryons is through their faint, but observable, X-ray signatures.



Our Universe

Astronomers use every appropriate means at their disposal to investigate the biggest questions in the Universe. In the past decade, Chandra has demonstrated that X-rays are a fundamental part of the modern astronomer's toolkit. Many wavelengths. One Universe.

Energy Distribution of the Universe



Download the Dark Universe podcast from
http://chandra.harvard.edu/resources/podcasts/sd.html

HOW MANY JELLY BEANS FILL A ONE-LITER CONTAINER?

There are many possible calculations, but this is one:

How big is a jelly bean?
A typical jelly bean would measure about 2 cm long by about 1.5 cm in diameter.

Do jelly beans completely fill the container?

The irregular shape of jelly beans result in them not being tightly packed; approximately 80% of the volume of the bottle is filled.

The number of jelly beans is the occupied volume of the container divided by the volume of a single jelly bean.

Number of beans = (occupied volume of container)/(volume of 1 Bean)

The volume of one jelly bean is approximated by the volume of a small cylinder 2 cm long and 1.5 cm in diameter.

Volume of 1 Jelly Bean =
pi x (1.5cm/2)^2 x 2 cm = 3.5 cubic centimeters

The approximate number of beans in the container is:
Number of beans = (.80 x 1000 cubic centimeters)/(3.5 cubic centimeters) = approx 229 jelly beans

Credits: **Jelly Bean Image:** Fermilab; **Pie Illustration:** NASA/CXC/M.Weiss; **Dark Energy:** NASA/STScI/G. Bacon; **Dark Matter:** 1E 0657-56: X-ray: NASA/CXC/CfA/M.Markevitch et al.; Optical: NASA/STScI; Magellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al.; **Observable Cosmos:** Earth Aurora: NASA/MSFC/CXC/A. Bhardwaj & R.Elsner, et al.; Earth model: NASA/GSFC/L.Perkins & G.Shirah; NGC 4696: X-ray: NASA/CXC/KIPAC/S.Allen et al; Radio: NRAO/VLA/G.Taylor; Infrared: NASA/ESA/McMaster Univ./W.Harris; **Galaxy Clusters:** Perseus Cluster: NASA/CXC/IoA/A.Fabian et al.; **Supernovas:** Cassiopeia A: NASA/CXC/MIT/UMass Amherst/M.D.Stage et al.; **Missing Baryons:** Mkn 421 Illustration: CXC/M.Weiss; **Our Universe:** M82: X-ray: NASA/CXC/JHU/D.Strickland; Optical: NASA/ESA/STScI/AURA/The Hubble Heritage Team; IR: NASA/JPL-Caltech/Univ. of AZ/C. Engelbracht

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