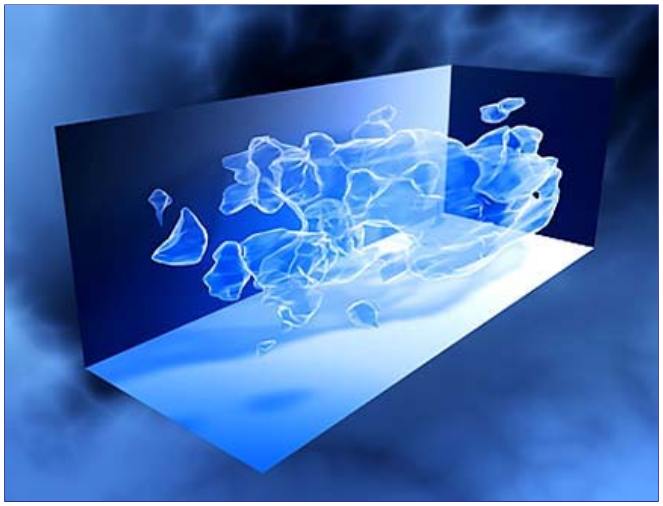
Universe's Mysterious Dark Matter - First 3-D Map

Without dark matter, there would have been insufficient mass in the universe for structures to collapse and galaxies to form. ...Normal matter - including stars, galaxies and gas - is built inside *an underlying scaffolding of dark matter."* - NASA/JPL



First 3-dimensional map of dark matter distribution in this universe moving from the early universe (left) to the more recent universe (right). Image credit NASA, ESA and R. Massey, Cal-Tech.

Age of Universe: 13.7 billion years

Composition:
.4% glowing matter such as stars.
3.6% "normal" matter as we know it in planets and stars.
23.0% cold, invisible "dark" matter detectable only by its gravitational influence on "normal" matter.
73.0% invisible "dark" energy.

January 7, 2007 Pasadena, California - The first three-dimensional map of large-scale distribution of dark matter in this universe has been produced from data collected by the Hubble Space Telescope's largest ever survey of the universe, the Cosmic Evolution Survey (COSMOS) and the European Space Agency's XMM-Newton orbiting telescope. Dark matter is an invisible form of matter that accounts for most of the universe's mass.

[Editor's Note: *Wikipedia* - "In astrophysics, dark matter is matter that does not emit or reflect enough electromagnetic radiation to be detected directly, but whose presence may be inferred from its gravitational effects on visible matter. Among the observed phenomena consistent with the existence of dark matter are the rotational speeds of galaxies and orbital velocities of galaxies in clusters, gravitational lensing of background objects by galaxy clusters such as the Bullet cluster, and the temperature distribution of hot gas in galaxies and clusters of galaxies.

"Dark matter also plays a central role in structure formation and Big Bang nucleosynthesis, and has measurable effects on the anisotropy of the cosmic microwave background. All these lines of evidence suggest that galaxies,

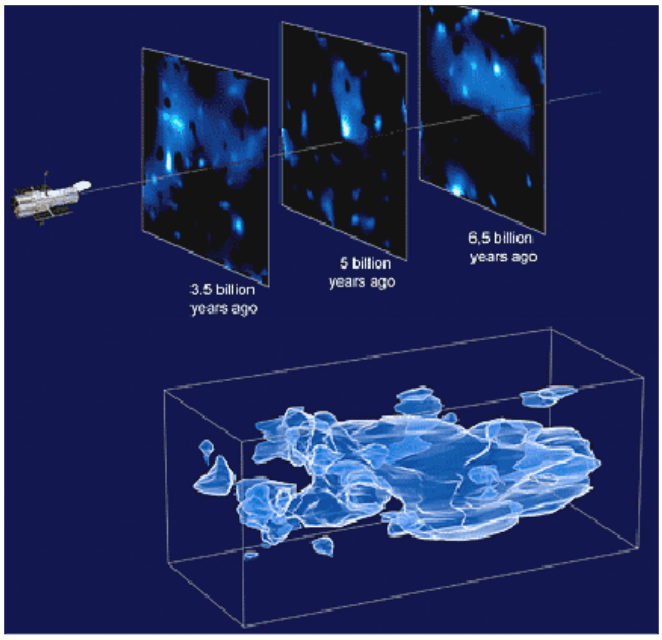
clusters of galaxies, and the universe as a whole contain far more matter than is directly observable, indicating that the remainder is dark.

"The composition of dark matter is unknown. Current evidence favors models in which the primary component of dark matter is new elementary particles, collectively called non-baryonic dark matter. The dark matter component has vastly more mass than the "visible" component of the universe. At present, the density of ordinary baryons and radiation in the universe is estimated to be equivalent to about one hydrogen atom per cubic meter of space. Only about 4% of the total energy density in the universe (as inferred from gravitational effects) can be seen directly. About 23% is thought to be composed of dark matter. The remaining 73% is thought to consist of dark energy, an even stranger component, distributed diffusely in space."]

NASA/JPL report that "because the dark matter can't be seen directly, its distribution on the sky is measured via weak gravitational lensing. This is the distortion of light from distant galaxies, rather like the effect of a funhouse mirror, due to the gravitational warping of space by dark matter along our line of sight. The Hubble Space Telescope's keen ability to measure these distortions allowed this map to be created with fine resolution. Constructing the entire map required the measurement of the shapes of half a million background galaxies and reveals a loose network of dark matter filaments, gradually collapsing under the relentless pull of gravity, and growing clumpier over time.

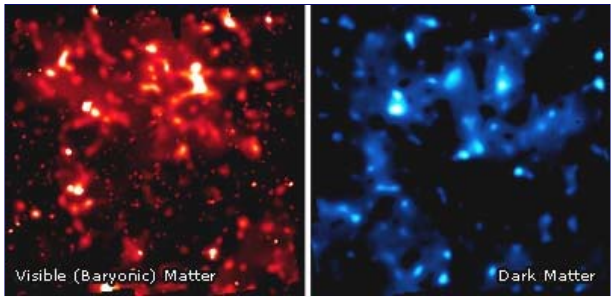
"The three axes of the box correspond to sky position (in right ascension and declination), and distance from the Earth increasing from left to right (as measured by cosmological redshift). Note how the clumping of the dark matter becomes more pronounced, moving right to left across the volume map, from the early universe to the more recent universe.

"This 3-D map confirms theories of how structure formed in our evolving Universe, which has transitioned from a comparatively smooth distribution of matter at the time of the big bang. The dark matter filaments began to form first and provided an underlying scaffolding for the subsequent construction of stars and galaxies from ordinary matter. Without dark matter, there would have been insufficient mass in the universe for structures to collapse and galaxies to form.

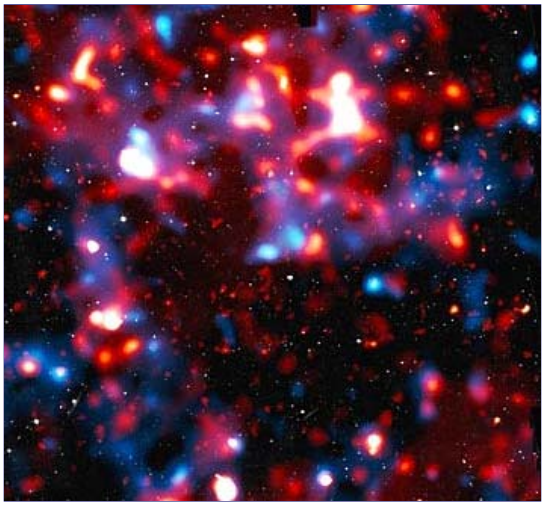


Three slices in time at 3.5 billion, 5 billion and 6.5 billion years ago look back into the universe's evolving dark matter past like coring through geologic strata. Image by NASA/JPL.

"The slices-of-time dataset above is created by splitting the background source galaxy population into three discrete epochs of time (like cutting through geologic strata), looking back into the past. This is calibrated by measuring the cosmological redshift of the lensing galaxies used to map the dark matter distribution, and binning them into different time/distance "slices." Each panel represents an area of sky nine times the angular diameter of the full Moon. Note that this fixed angle means that the survey volume is really a cone, and that the physical area of the slices increases from 60 million light-years on a side to 100 million light-years on a side from left to right.



These two false-color images compare the distribution of normal matter (red) with dark matter (blue) in the universe. The brightness of clumps corresponds to the density of mass. The map covers an area of sky nine times the angular diameter of the full Moon, and is the largest sample of the distribution of dark matter ever obtained. It demonstrates how normal matter - including stars, galaxies and gas - is built *inside* an underlying scaffolding of dark matter.



This composite shows three different components of the Hubble COSMOS survey. The normal matter is in red, determined mainly by the European Space Agency's XMM/Newton telescope. The dark matter is in blue. The stars and galaxies are white-grey observed in visible light with Hubble. Images credit: NASA, ESA and R. Massey, Cal-Tech.

"The Hubble Space Telescope has a narrow field of view, which is only a fraction of the angular diameter of the Moon. Certain research programs have devoted a substantial amount of Hubble observing time to survey comparatively larger areas of sky to address a wide range of galaxy evolution and cosmological questions. This is accomplished by assembling mosaic images taken with Hubble's cameras. These surveys constrain the star formation history of the universe, probing the faintest galaxies and tracking the origin, structure, and merger history of galaxies as they evolve."

More Information:

This first 3-D map of dark matter distribution in the universe was derived from the Hubble Space Telescope's largest ever survey of the universe, the Cosmic Evolution Survey (COSMOS), carried out by an international team of 70 astronomers. In making the COSMOS survey, Hubble photographed 575 adjacent and slightly overlapping views of the universe using the Advanced Camera for Surveys' (ACS) Wide Field Camera onboard Hubble. It took nearly 1,000 hours of observations. The distances to the galaxies were determined from their spectral redshifts, using the Subaru telescope in Hawaii. The distribution of additional gas outside galaxies was measured with the European Space Agency's XMM/Newton telescope.

For further information about dark matter and energy, please see the **Earthfiles Archives** below.

- 01/17/2004 -- Part 2 - Is Dark Matter the "Heavy Shadow" of Light Matter?
- 01/13/2004 -- Part 1 - Is Dark Matter the "Heavy Shadow" of Visible Matter?
- 10/25/2003 -- Science Data Reinforces Invisible "Dark" Matter and Energy Make Up 96% of Our Universe
- 02/24/2002 -- Mysterious Slowing of Pioneer Spacecraft 7 Billion Miles from Earth
- 12/20/2001 -- Will Our Universe End With Its Final Light Frozen in Time?
- 12/14/2000 -- A Pleiadian Star Tears Apart Black Interstellar Cloud
- 02/01/1999 -- Astronomy Updates with Brian Marsden and John Huchra, Harvard

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Websites:

European Space Agency: http://www.esa.int/esaCP/index.html

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