

# Dark Matter and Dark Energy

المادة الخفية والطاقة الخفية

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# ما هو أصل الكون؟ ومتى بدأ؟ وما هو مصيره؟

■ نظرية الانفجار الأعظم (Big Bang Theory)

■ بداية القرن العشرين (Friedmann)

the cosmological principle (which says that basic physical properties are the same throughout the universe) and Albert Einstein's General Theory of Relativity of 1915-1916, which conceives of gravity as a curvature in space and time.

■ وعززت منتصف القرن العشرين ونهايته.

- The beginning before 13.7 billion years.
  - The Planck era was extremely brief—just  $10^{-43}$  seconds
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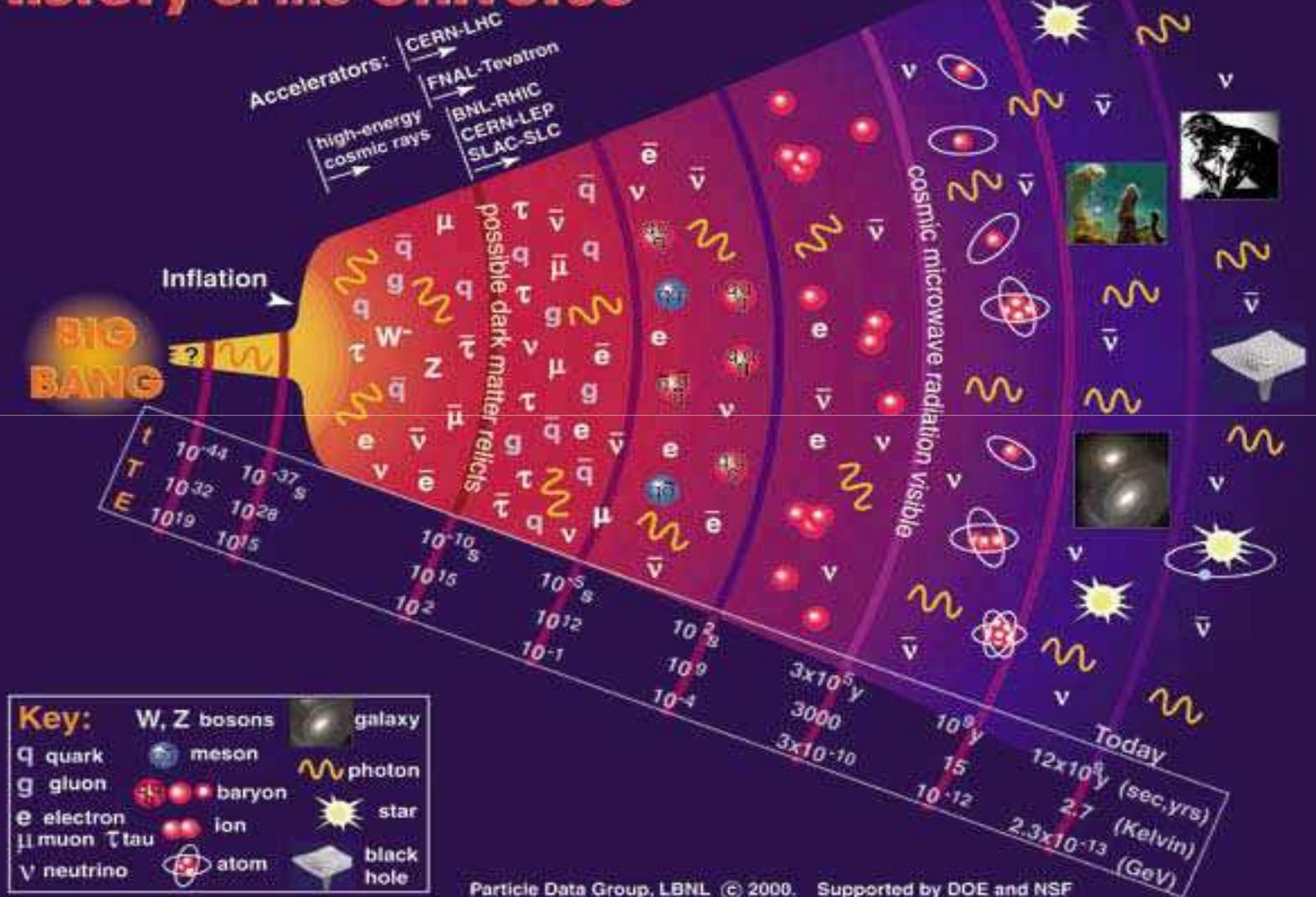
- During this period, all four forces of the universe—gravity, electromagnetic energy, and the weak and strong nuclear forces—were theoretically equal to one another, implying that there may have been just one unified force.
- The Planck era was extremely unstable, with the four forces quickly evolving into their current forms, starting with gravity and then the strong nuclear force (what binds protons and neutrons together in the nucleus of an atom), the weak nuclear force (associated with radioactive decay, it is some 100 times weaker than the strong force), and finally electromagnetic energy.

- “inflation era.” Physicists, however, are not certain of the energy force that led to this inflation.
- At one second in age, the universe now consisted of fundamental energy and sub-atomic particles such as quarks, electrons, photons, and other less familiar particles.

- The next stage in the Big Bang—lasting for roughly 100,000 years consisted of the process of nucleosynthesis, as protons and neutrons came into being and began to form the nuclei of various elements, predominantly hydrogen and helium.
- The universe essentially consisted of radiation in the form of light, radio waves, and X-rays. This period, known as the “radiation era,” came to a gradual end as free floating atomic nuclei bonded with free-floating electrons to produce the matter.

- It took some 200 million years for gravity to begin coalescing these free-floating atoms into the primordial gas out of which the first stars and galaxies would emerge.
- Over billions of years, such early stars and galaxies phased through their lifecycle, using up their nuclear fuel and collapsing in on themselves.
- The sun around which the earth and the solar system rotate is one of these later generation stars, formed roughly five billion years ago.

# History of the Universe



## ما هو مصير الكون؟

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- The **Big Bang** theory concerns not just the **origins of the universe** but its **ultimate fate**.
- The critical question, of course, is whether the universe will **continue expanding** forever
- or **eventually fall back into itself**, creating, perhaps, the conditions for the **next Big Bang**.

## ثلاثة احتمالات ممكنة

- The first, and most widely accepted by physicists, is that there is not the critical density, known as  $\omega$  and estimated at roughly six hydrogen atoms per cubic meter, necessary to pull the universe back in on itself. In this model, referred to as the “open” model, the universe will continue to expand and cool indefinitely.
- If however, the density of the universe is greater than  $\omega$  then the universe will eventually, after billions of years, collapse in what physicists call the “big crunch.”
- A third and highly unlikely possibility is that  $\omega$  equals precisely one; in this model, the universe gradually slows and cools to a static state.

## أدلة على وجود مادة خفية

- For example, the **Andromeda galaxy**, the nearest neighbor to our own Milky Way galaxy, is rushing toward us at 200,000 miles per hour, a speed that cannot be explained by the gravitational force of the matter in the two galaxies.
- In fact, the two galaxies are coming together at a pace requiring some 10 times that amount of matter. Physicists offer the possibility that there is **dark matter** in the universe, that is, an unknown type of matter that does not emit or reflect enough electromagnetic energy to be observable by current means.

## دليل آخر

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- A team of astronomers has discovered the least luminous, most **dark matter-filled** galaxy known to exist. The **Segue 1 galaxy** is one of about two dozen small satellite galaxies orbiting our own Milky Way.
- This is a very faint galaxy, a billion times less bright than the Milky Way. But despite its small number of visible stars, Segue 1 is nearly a thousand times more massive than it appears, meaning most of its mass must come from **dark matter**.

## دراسة حديثة

- Scientists (~~University of Zurich and the~~ University of Central Lancashire) are trying to understand the invisible and hypothetical '**dark matter**' the stuff that we know exists by inference of its gravitational influence on the matter we **can** see.
- The most common held notion of **dark matter** is that it exists in 'halos' or clumps that surround galaxies. But a new study predicts that galaxies like our own Milky Way, also contain a *disk* of **dark matter**.

# نظريات حديثة حول المادة الخفية

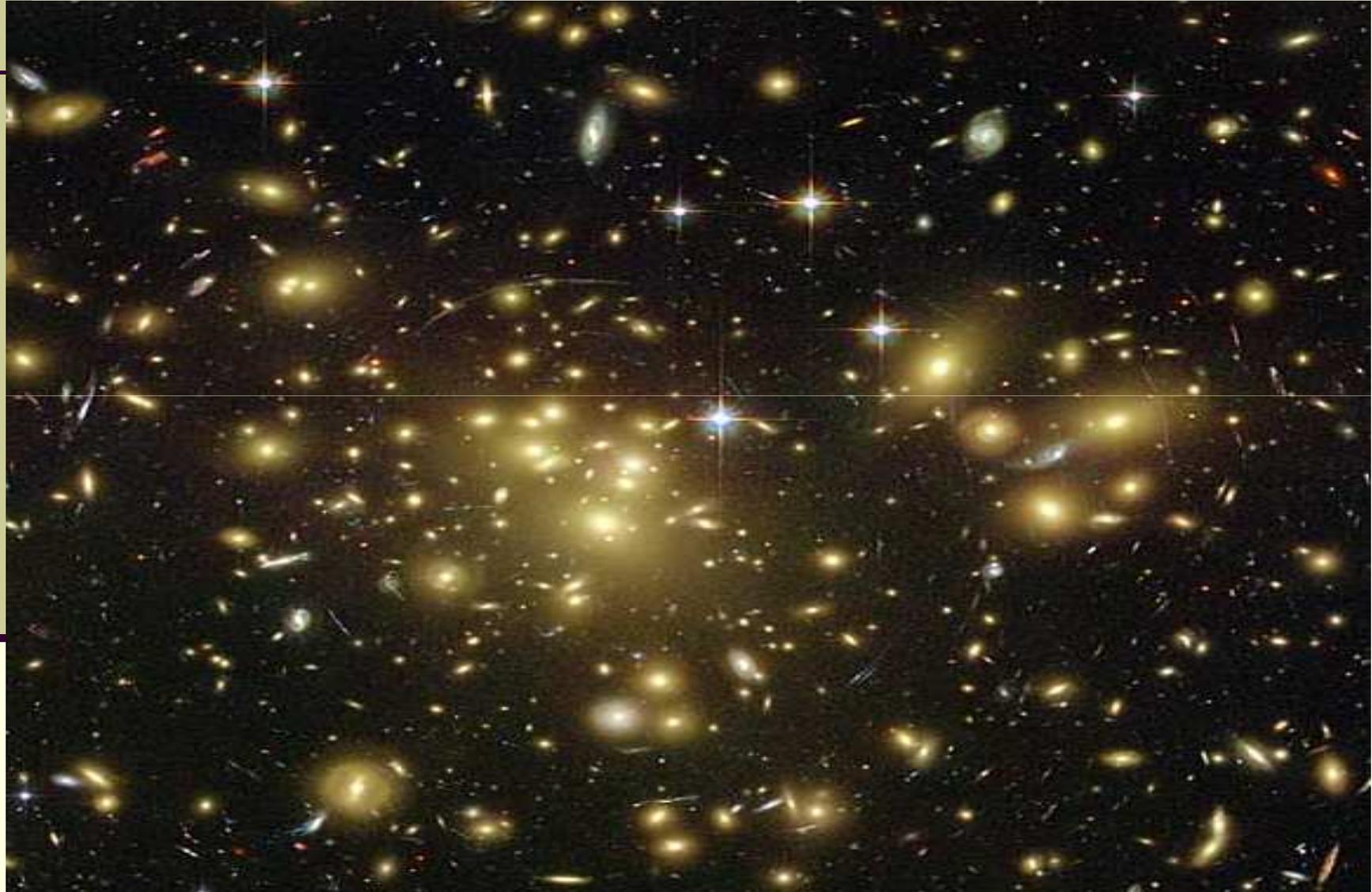
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- The first stars to light the early universe may have been powered by **dark matter**, according to a new study.
- Researchers from the University of Michigan, Ann Arbor call these very first stars "**Dark Stars**," and propose that **dark matter** heating provided the energy for these stars instead of fusion.

- The researchers propose that with a high concentration of **dark matter** in the early Universe,
- the theoretical particles called **Weakly Interacting Massive Particles (WIMPs)**,
- collected inside the first stars and annihilated themselves to produce a **heat source** to power the stars.

- Such **dark matter**, according to this hypothesis, exists in **haloes** around **galaxies** and may be what composes **black holes** and **massive clouds** of **neutrinos**, particles formed from radioactive decay with little mass and no electric charge.
- Such **dark matter** would imply a **universe** that eventually **collapses** in on itself, **except** for an additional **complicating factor**.

# Hubble Advanced Camera



- **Hubble Space telescope** in the 1990s.
- The **Giant Magellan Telescope**, or GMT, will have the resolving power of a single **24.5-meter primary mirror**
- With the development of ever more **powerful computers**.
- **Dark energy** was discovered in **1998** during a survey of **distant supernova**. Instead of finding evidence that the mutual gravity of all the objects in the **Universe** is slowing down its expansion, researchers discovered that its expansion is **actually accelerating**.

# مراقبة (السويزنوبا) البعيدة



# Accelerating Universe

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- Recent observations suggest expansion of the Universe is accelerating
- What can cause this?
  - Something that has *negative* pressure (!)

**Dark Energy**

## دراسة حديثة حول الطاقة الخفية

- A new paper published by Dartmouth university researcher Brian Chaboyer reports that our universe might be dominated by "**dark energy**"; a mysterious force that seems to be causing objects in the universe to **accelerate away** from each other.
- The researchers came to this conclusion by calculating the **age of distant globular clusters**, and matching it to the expansion age of the universe. The numbers **only match** if the universe has been **accelerating** up until now.

# العنايف النجمية البعيدة

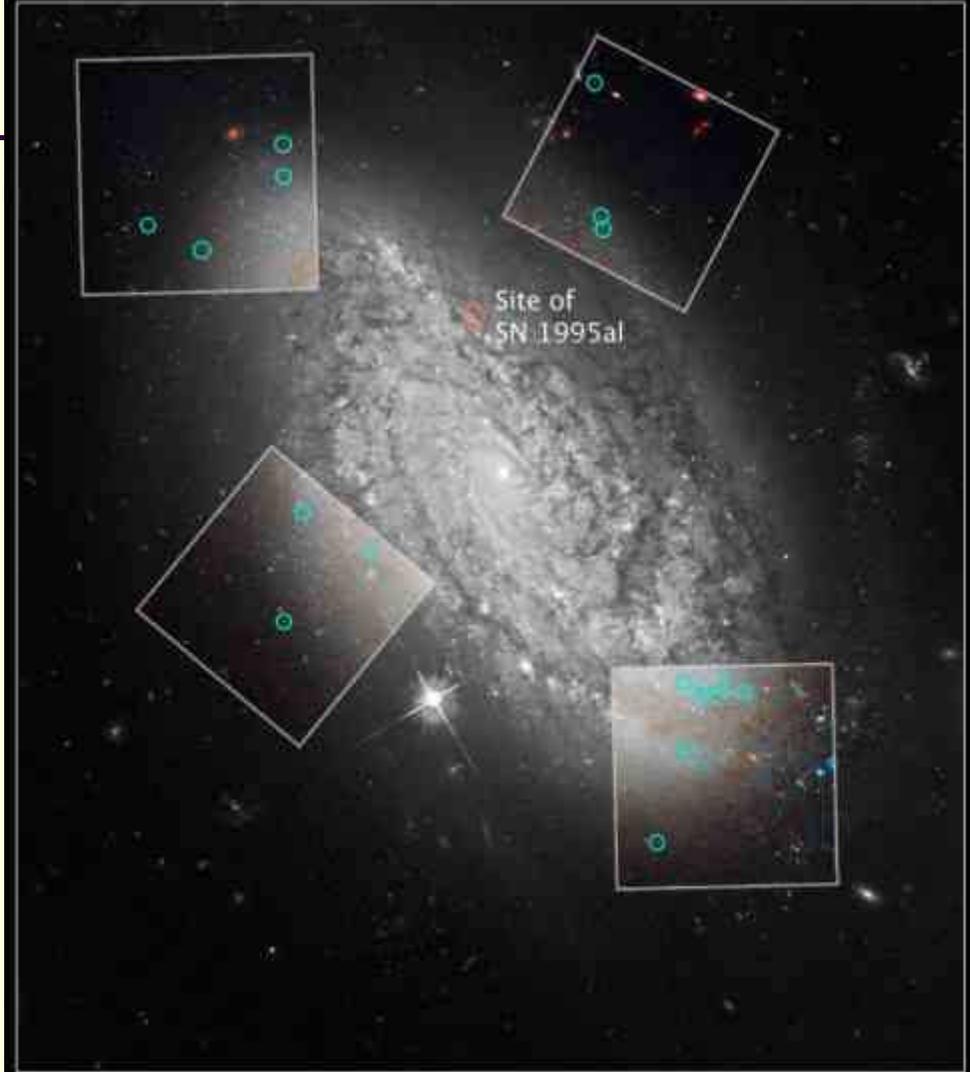


# معدل تمدد الكون

- New observations of several **Cepheid variable stars** by the **Hubble Space Telescope** has refined the measurement **of the Universe**'s present expansion rate to a precision where the error is smaller than five percent.
- The new value for the expansion rate, known as the **Hubble constant**, or  $H_0$  (after Edwin Hubble who first measured the expansion of the **universe** nearly a century ago), is **74.2 kilometers per second per megaparsec**

Spiral Galaxy NGC 3021

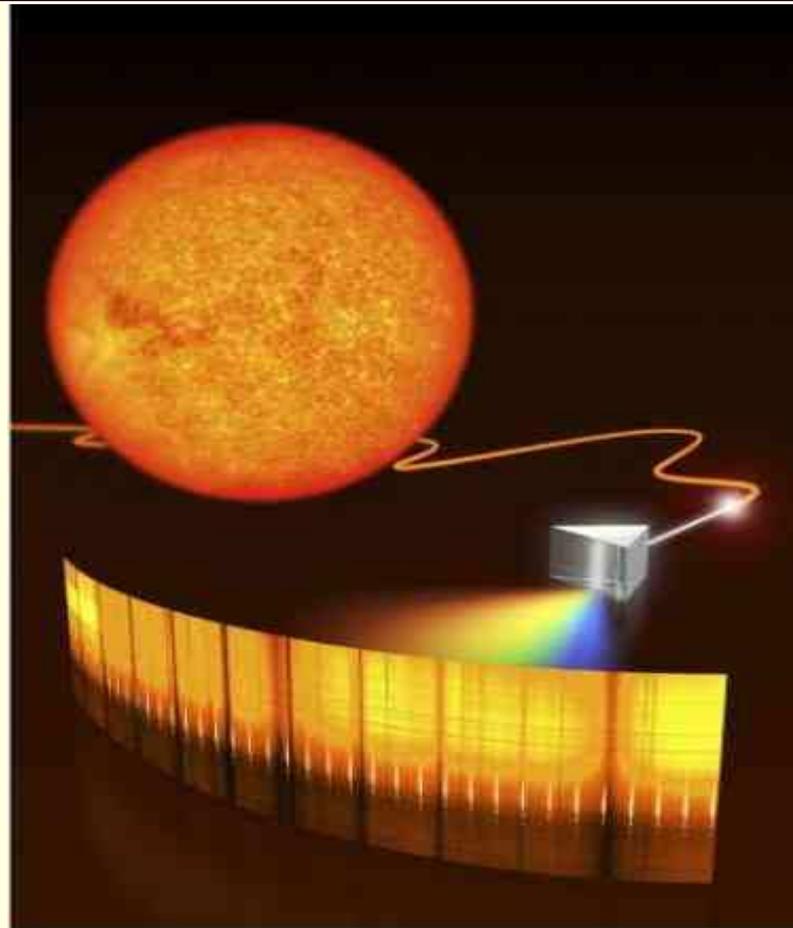
HST • ACS/WFC • NICMOS



NASA, ESA, and A. Riess (STScI/JHU)

STScI-PRC09-08a

# 'Laser Comb' To Measure the Accelerating Universe



A Laser Comb for Astronomy  
(Artist's Impression)

ESO Press Photo 20a/08 (4 September 2008)



- The device uses **femto-second** (one millionth of one billionth of a second) **pulses of laser light** coupled with an **atomic clock** to provide a precise standard for measuring **wavelengths of light**.
- Also known these devices should give astronomers the ability to use the **Doppler shift method** with **incredible precision** to measure **spectral lines of starlight** up to **60 times greater than any current high-tech method**. Astronomers have been testing the device, and hope to use one in conjunction with the new **Extremely Large Telescope** which is being designed by **ESO**, the **European Southern Observatory**.

- According to British scientist **Robert Caldwell**, this accelerating expansion may lead

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to what he calls the “**big rip**,” in which galaxies, stars, and even atoms are eventually torn apart by the force of **dark energy**, leading to the destruction of matter in the final seconds of time at the end of the universe.

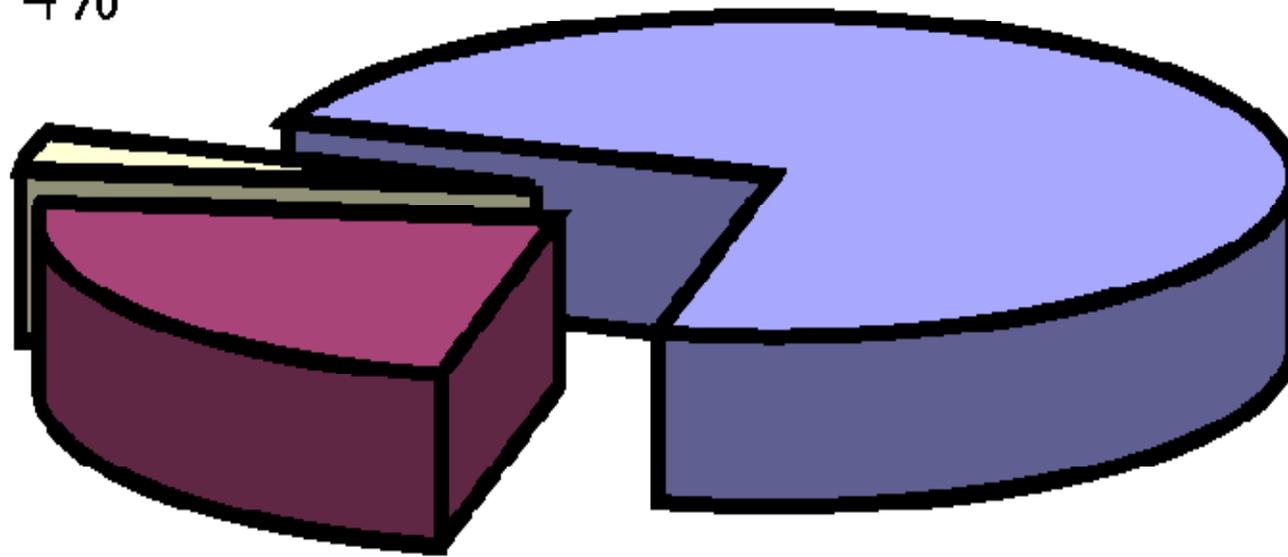
- Much of this work on **dark matter** and **energy** remains hypothetical, of course, as it has been impossible to detect either of these two phenomena.

- Dr Zhao points out, "Both dark matter and dark energy could be two faces of the same coin."
- "As astronomers gain understanding of the subtle effects of dark energy in galaxies in the future, we will solve the mystery of astronomical dark matter at the same time."

Atoms  
4%

Dark energy  
73%

Dark matter  
23%



# مهمة الفلكيين والفيزيائيين للقرن الواحد والعشرين

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■ الكشف عن المادة الخفية والطاقة الخفية.

■ استقصاء مصير الكون !