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Space Image of the Week
Astrophysicists have a fairly accurate understanding of how the universe ages. That's the conclusion of new results from the Dark Energy Survey (DES), a large international science collaboration, including researchers from the Department of Energy's SLAC National Accelerator Laboratory, that put models of cosmic structure formation and evolution to the most precise test yet.

The survey's researchers analyzed light from 26 million galaxies to study how structures in the universe have changed over the past 7 billion years - half the age of the universe. The data were taken with the DECam, a 570-megapixel camera attached to the 4-meter Victor M. Blanco Telescope at the Cerro Tololo Inter-American Observatory in Chile.

Previously, the most precise test of cosmological models came from measurements with the European Space Agency's Planck satellite of what is known as the cosmic microwave background (CMB) - a faint glow in the sky emitted 380,000 years after the Big Bang. "While Planck looked at the structure of the very early universe, DES has measured structures that evolved much later," said Daniel Gruen, a NASA Einstein postdoctoral fellow at the Kavli Institute for Particle Astrophysics and Cosmology (KIPAC), a joint institute of Stanford University and SLAC. "The growth of these structures from the early ages of the universe until today agrees with what our models predict, showing that we can describe cosmic evolution very well."

Gruen will present the results, which are based on the first year of data from the 5-year-long survey, today at the 2017 Division of Particles and Fields meeting of the American Physical Society at the DOE's Fermi National Accelerator Laboratory.

KIPAC faculty member Risa Wechsler, a founding member of DES, said, "For the first time, the precision of key cosmological parameters coming out of a galaxy survey is comparable to the ones derived from measurements of the cosmic microwave background. This allows us to test our models independently and combine both approaches to obtain parameter values with unprecedented precision."

**Largest Map of Mass Distribution**

The standard model of cosmology, called Lambda-CDM, includes two key ingredients. Cold dark matter (CDM), an invisible form of matter that is five times more prevalent than regular matter, clumps together and is at the heart of
the formation of structures such as galaxies and galaxy clusters. Lambda, the cosmological constant, describes the accelerated expansion of the universe, driven by an unknown force referred to as dark energy.

Astrophysicists need precise tests of the model because its ingredients are not completely certain. Dark matter has never been directly detected. Dark energy is even more mysterious, and it's not known whether it actually is a constant or changes over time.

DES has now succeeded in carrying out such a precision test. The scientists used the fact that images of faraway galaxies get slightly distorted by the gravity of galaxies in the foreground - an effect known as weak gravitational lensing. This analysis led to the largest map ever constructed for the distribution of mass - both regular and dark matter - in the universe, as well as its evolution over time.

"Within an error bar of less than 5 percent, the combined Planck and DES results are consistent with Lambda-CDM," Wechsler said. "This also means that, so far, we don't need anything but a constant form of dark energy to describe the expansion history of the universe."

Key Contributions from KIPAC

In addition to Gruen, who led the weak lensing working group, and Wechsler, whose group provided realistic simulations of the survey critical to testing several aspects of the cosmological analysis, a large number of KIPAC scientists, postdoctoral fellows, graduate students and alumni have made crucial contributions to DES - from building the instrument to developing theory and simulations and analyzing the data.

Postdoctoral fellow Elisabeth Krause, for example, leads the DES theory and combined probes working group. In that role, she led the charge in developing theoretical models that match the experimental precision obtained with the DES data. This involved writing computer codes that calculate what weak gravitational lensing should look like for a given model.

"Different people develop slightly different codes that are meant to do the same thing," she said. "I helped bring code developers together to cross-check their results and to make sure that we get the most precise theory codes possible."

Another key to the creation of the mass distribution map was to accurately determine the distances to the observed galaxies - information that is usually derived from independent surveys that analyze the properties of light coming from those objects or from exploding stars. "We've shown that we can use the color of certain red galaxies - red is the color they would have if you were right in front of them - to determine how far they are away," said SLAC staff scientist Eli Rykoff, who had a leading role in this part of the analysis. "It turns out that if we map where these red galaxies are in the sky, we can use them to calibrate the distances of the lenses and background galaxies used in the study."

Toward Even Deeper Cosmic Insights

In the near future, more DES data will allow astrophysicists to test their cosmological models with even more precision. The analysis of data collected during the first three years of the survey will begin soon, and the fifth year of observations will also soon be underway.

With even better data, the researchers said, we might find out if the relatively simple Lambda-CDM model needs to be modified. "The methods developed for DES and the experience its researchers are gaining along the way will also benefit the natural flow of ever-evolving experiments," said KIPAC faculty member David Burke, head of SLAC's DES group.

Both will prepare scientists for future surveys, including ones with the Large Synoptic Survey Telescope (LSST). With its 3.2-gigapixel camera, which is under construction at SLAC, astrophysicists will be able to explore the depths of our universe like never before.

Source: Spaceref.com
2. New Horizons' Next Target Just Got a Lot More Interesting

Could the next flyby target for NASA’s New Horizons spacecraft actually be two targets?

New Horizons scientists look to answer that question as they sort through new data gathered on the distant Kuiper Belt object (KBO) 2014 MU69, which the spacecraft will fly past on Jan. 1, 2019. That flyby will be the most distant in the history of space exploration, a billion miles beyond Pluto.

The ancient KBO, which is more than four billion miles (6.5 billion kilometers) from Earth, passed in front of a star on July 17, 2017. A handful of telescopes deployed by the New Horizons team in a remote part of Patagonia, Argentina were in the right place at the right time to catch its fleeting shadow — an event known as an occultation — and were able to capture important data to help mission flyby planners better determine the spacecraft trajectory and understand the size, shape, orbit and environment around MU69.

Based on these new occultation observations, team members say MU69 may not be not a lone spherical object, but suspect it could be an “extreme prolate spheroid” — think of a skinny football — or even a binary pair. The odd shape has scientists thinking two bodies may be orbiting very close together or even touching — what’s known as a close or contact binary — or perhaps they’re observing a single body with a large chunk taken out of it. The size of MU69 or its components also can be determined from these data. It appears to be no more than 20 miles (30 kilometers) long, or, if a binary, each about 9-12 miles (15-20 kilometers) in diameter.
“This new finding is simply spectacular. The shape of MU69 is truly provocative, and could mean another first for New Horizons going to a binary object in the Kuiper Belt,” said Alan Stern, mission principal investigator from the Southwest Research Institute (SwRI) in Boulder, Colorado. “I could not be happier with the occultation results, which promise a scientific bonanza for the flyby.”

The July 17 stellar occultation event that gathered these data was the third of a historic set of three ambitious occultation observations for New Horizons. The team used data from the Hubble Space Telescope and European Space Agency’s Gaia satellite to calculate and pinpoint where MU69 would cast a shadow on Earth's surface. “Both of these space satellites were crucial to the success of the entire occultation campaign,” added Stern.

Said Marc Buie, the New Horizons co-investigator who led the observation campaign, “These exciting and puzzling results have already been key for our mission planning, but also add to the mysteries surrounding this target leading into the New Horizons encounter with MU69, now less than 17 months away.”

Follow the mission and observation campaign at the NASA New Horizons website and the mission's KBO Chasers page.

Source: NASA
3. Hubble Detects Exoplanet with Glowing Water Atmosphere

Scientists have discovered the strongest evidence to date for a stratosphere on a planet outside our solar system, or exoplanet. A stratosphere is a layer of atmosphere in which temperature increases with higher altitudes.

"This result is exciting because it shows that a common trait of most of the atmospheres in our solar system -- a warm stratosphere -- also can be found in exoplanet atmospheres," said Mark Marley, study co-author based at NASA's Ames Research Center in California's Silicon Valley. "We can now compare processes in exoplanet atmospheres with the same processes that happen under different sets of conditions in our own solar system."

Reporting in the journal Nature, scientists used data from NASA's Hubble Space Telescope to study WASP-121b, a type of exoplanet called a "hot Jupiter." Its mass is 1.2 times that of Jupiter, and its radius is about 1.9 times Jupiter's -- making it puffier. But while Jupiter revolves around our sun once every 12 years, WASP-121b has an orbital period of just 1.3 days. This exoplanet is so close to its star that if it got any closer, the star's gravity would start ripping it apart. It also means that the top of the planet's atmosphere is heated to a blazing 4,600 degrees Fahrenheit (2,500 Celsius), hot enough to boil some metals. The WASP-121 system is estimated to be about 900 light years from Earth -- a long way, but close by galactic standards.

Previous research found possible signs of a stratosphere on the exoplanet WASP-33b as well as some other hot Jupiters. The new study presents the best evidence yet because of the signature of hot water molecules that researchers observed for the first time.

"Theoretical models have suggested stratospheres may define a distinct class of ultra-hot planets, with important implications for their atmospheric physics and chemistry," said Tom Evans, lead author and research fellow at the University of Exeter, United Kingdom. "Our observations support this picture."

To study the stratosphere of WASP-121b, scientists analyzed how different molecules in the atmosphere react to particular wavelengths of light, using Hubble's capabilities for spectroscopy. Water vapor in the planet's
atmosphere, for example, behaves in predictable ways in response to certain wavelengths of light, depending on the temperature of the water.

Starlight is able to penetrate deep into a planet's atmosphere, where it raises the temperature of the gas there. This gas then radiates its heat into space as infrared light. However, if there is cooler water vapor at the top of the atmosphere, the water molecules will prevent certain wavelengths of this light from escaping to space. But if the water molecules at the top of the atmosphere have a higher temperature, they will glow at the same wavelengths.

"The emission of light from water means the temperature is increasing with height," said Tiffany Kataria, study co-author based at NASA's Jet Propulsion Laboratory, Pasadena, California. "We're excited to explore at what longitudes this behavior persists with upcoming Hubble observations."

The phenomenon is similar to what happens with fireworks, which get their colors from chemicals emitting light. When metallic substances are heated and vaporized, their electrons move into higher energy states. Depending on the material, these electrons will emit light at specific wavelengths as they lose energy: sodium produces orange-yellow and strontium produces red in this process, for example. The water molecules in the atmosphere of WASP-121b similarly give off radiation as they lose energy, but in the form of infrared light, which the human eye is unable to detect.

In Earth's stratosphere, ozone gas traps ultraviolet radiation from the sun, which raises the temperature of this layer of atmosphere. Other solar system bodies have stratospheres, too; methane is responsible for heating in the stratospheres of Jupiter and Saturn's moon Titan, for example.

In solar system planets, the change in temperature within a stratosphere is typically around 100 degrees Fahrenheit (about 56 degrees Celsius). On WASP-121b, the temperature in the stratosphere rises by 1,000 degrees (560 degrees Celsius). Scientists do not yet know what chemicals are causing the temperature increase in WASP-121b's atmosphere. Vanadium oxide and titanium oxide are candidates, as they are commonly seen in brown dwarfs, "failed stars" that have some commonalities with exoplanets. Such compounds are expected to be present only on the hottest of hot Jupiters, as high temperatures are needed to keep them in a gaseous state.

"This super-hot exoplanet is going to be a benchmark for our atmospheric models, and it will be a great observational target moving into the Webb era," said Hannah Wakeford, study co-author who worked on this research while at NASA's Goddard Space Flight Center, Greenbelt, Maryland.

The Hubble Space Telescope is a project of international cooperation between NASA and ESA (European Space Agency). NASA's Goddard Space Flight Center in Greenbelt, Maryland, manages the telescope. The Space Telescope Science Institute (STScI) in Baltimore, Maryland, conducts Hubble science operations. STScI is operated for NASA by the Association of Universities for Research in Astronomy, Inc., in Washington. Caltech manages JPL for NASA.

For more information about Hubble, visit https://nasa.gov/hubble or http://hubblesite.org.

For more information about exoplanets, visit https://exoplanets.nasa.gov.

Source: NASA
**The Night Sky**

**Friday, August 4**

- As soon as it's dark, look lower right of the bright Moon for the Teapot of Sagittarius. It's about the size of your fist at arm's length, tilting to pour to the right, as shown here.

**Saturday, August 5**

- The Moon shines low in the southeast as the stars come out. How early can you spot Altair, three fists at arm's length to the Moon's upper left? How about brighter Vega, now nearing the zenith from the east?

**Sunday, August 6**

- Bright Vega passes closest to overhead around 10 or 11 p.m., depending on how far east or west you are in your time zone. How closely it misses your zenith depends on how far north or south you are. It passes right through your zenith if you're at latitude 39° north (Washington DC, Cincinnati, Kansas City, Lake Tahoe). How closely can you judge this just by looking?

**Monday, August 7**

- Full Moon (exact at 2:11 p.m. EDT). The Moon rises around sunset. Once it's dark, can you see through the moonlight that it's in dim Capricornus? That's about where the full Moon at this time of year always resides.

- A shallow partial eclipse of the Moon is visible tonight from eastern Europe, most of Africa and Asia, and Australia. Details. By no coincidence, we're two weeks — half a lunar orbit — from the total eclipse of the Sun on August 21st.

Source: Sky & Telescope
ISS Sighting Opportunities

For Denver:

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Sighting information for other cities can be found at NASA's [Satellite Sighting Information](https://www.nasa.gov/mission_pages/station/sm/sightings2.html).

**NASA-TV Highlights**
(all times Eastern Daylight Time)

**August 4**
- 6 p.m., Friday, Replay of SpaceCast Weekly (all channels)
- 9 p.m., Replay of SpaceCast Weekly (all channels)

**Monday, August 7**
- TBD, ISS Expedition 52 In-Flight Educational Event with the Boy Scouts of the Bay Area in Pleasant Hill, California and NASA Flight Engineer Jack Fischer (all channels)


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Space Calendar

- Aug 04 - Comet 2P/Encke At Opposition (1.288 AU)
- Aug 04 - Apollo Asteroid 2011 CN22 Near-Earth Flyby (0.040 AU)
- Aug 04 - Asteroid 12485 jenniferharris Closest Approach To Earth (1.216 AU)
- Aug 04 - Asteroid 4970 Druyan Closest Approach To Earth (1.484 AU)
- Aug 04 - Asteroid 216 Kleopatra Closest Approach To Earth (1.670 AU)
- Aug 04 - Asteroid 6676 Monet Closest Approach To Earth (2.626 AU)
- Aug 05 - 5th Anniversary (2012), Mars Science Laboratory (MSL), Mars Landing
- Aug 05 - Comet 339P/Gibbs Closest Approach To Earth (2.688 AU)
- Aug 05 - Comet 116P/Wild Closest Approach To Earth (2.866 AU)
- Aug 05 - Apollo Asteroid 2017 OR19 Near-Earth Flyby (0.059 AU)
- Aug 05 - Kuiper Belt Object 2008 OG19 At Opposition (37.654 AU)
- Aug 05 - Brian Marsden's 80th Birthday (1937)
- Aug 05 - Niels Abel's 215th Birthday (1802)
- Aug 06 - Southern Iota Aquarids Meteor Shower Peak
- Aug 06 - Comet 189P/NEAT Perihelion (1.213 AU)
- Aug 06 - Comet 353P/McNaught Closest Approach To Earth (1.461 AU)
- Aug 06 - Comet 259P/Garradd Perihelion (1.809 AU)
- Aug 06 - Comet 171P/Spahr At Opposition (3.037 AU)
- Aug 06 - Asteroid 5247 Krylov Occults HIP 104172 (6.1 Magnitude Star)
- Aug 06 - Apollo Asteroid 2017 NB7 Near-Earth Flyby (0.017 AU)
- Aug 06 - Apollo Asteroid 2017 OJ7 Near-Earth Flyby (0.078 AU)
- Aug 06 - Asteroid 1258 Sicilia Closest Approach To Earth (2.108 AU)
- Aug 06 - Sylvain Arend's 115th Birthday (1902)
- Aug 06 - Johann Bernoulli's 350th Birthday (1667)
- Aug 07 - Partial Lunar Eclipse
- Aug 07 - Cassini, Distant Flyby of Janus, Atlas & Epimetheus
- Aug 07 - Comet 236P/LINEAR At Opposition (1.118 AU)
- Aug 07 - Comet C/2017 D2 (Barros) Closest Approach To Earth (1.506 AU)
- Aug 07 - Apollo Asteroid 1991 VG Near-Earth Flyby (0.057 AU)
- Aug 07 - Amor Asteroid 2017 OE20 Near-Earth Flyby (0.064 AU)
- Aug 07 - Apollo Asteroid 2007 PS9 Near-Earth Flyby (0.077 AU)
- Aug 07 - Apollo Asteroid 2017 OL7 Near-Earth Flyby (0.085 AU)
- Aug 07 - Apollo Asteroid 2016 YR Near-Earth Flyby (0.095 AU)
- Aug 07 - Asteroid 3672 Stevedberg Closest Approach To Earth (1.171 AU)
- Aug 07 - Asteroid 8664 Grigorijrichters Closest Approach To Earth (1.279 AU)
- Aug 07 - Asteroid 3351 Smith Closest Approach To Earth (1.527 AU)
- Aug 07 - Asteroid 5553 Chodas Closest Approach To Earth (2.217 AU)
- Aug 07 - 20th Anniversary (1997), STS-85 Launch (Space Shuttle Discovery, CRISTA-SPAS)

Source: JPL Space Calendar
Food for Thought

Five Years Ago and 154 Million Miles Away: Touchdown!

NASA's Curiosity Mars rover, which landed near Mount Sharp five years ago this week, is examining clues on that mountain about long-ago lakes on Mars.

On Aug. 5, 2012, the mission team at NASA's Jet Propulsion Laboratory in Pasadena, California, exalted at radio confirmation and first images from Curiosity after the rover's touchdown using a new "sky crane" landing method. Transmissions at the speed of light took nearly 14 minutes to travel from Mars to Earth, which that day were about 154 million miles (248 million kilometers) apart.

Those first images included a view of Mount Sharp. The mission accomplished its main goal in less than a year, before reaching the mountain. It determined that an ancient lake environment on this part of Mars offered the conditions needed for life -- fresh water, other key chemical ingredients and an energy source.

On Mount Sharp since 2014, Curiosity has examined environments where both water and wind have left their marks. Having studied more than 600 vertical feet of rock with signs of lakes and later groundwater, Curiosity's international science team concluded that habitable conditions lasted for at least millions of years. With higher destinations ahead, Curiosity will continue exploring how this habitable world changed through time. For more about the mission, visit https://mars.jpl.nasa.gov/msl.

Source: NASA
**Space Image of the Week**

**North North Temperate Zone Little Red Spot**

**Explanation:** On July 11, the Juno spacecraft once again swung near the turbulent Jovian cloud tops. On its seventh orbital closest approach this [perijove passage](#) brought Juno within 3,500 kilometers of the Solar System's largest planetary atmosphere. Near perijove the rotating JunoCam was able to record [this stunning, clear view](#) of one of Jupiter's [signature vortices](#). About 8,000 kilometers in diameter, the anticyclonic storm system was spotted in Jupiter's [North North Temperate Zone](#) in the 1990s. That makes it about half the size of an older and better known Jovian anticyclone, the [Great Red Spot](#), but only a little smaller than planet Earth. At times taking on reddish hues, the enormous storm system is fondly known as a [North North Temperate Zone Little Red Spot](#).

**Image Credit:** [NASA](#), [JPL-Caltech](#), [SwRI](#), [MSSS](#); **Processing:** [Gerald Eichstadt](#), [Damian Peach](#)

Source: [APOD](#)