**Calendar of Events**

**FRIDAY Nov. 13**
7:30 PM
3139 Wescoe Hall
*Cub Scout Astronomy Night*

**FRIDAY Dec. 11**
7:30 PM
2001 Malott Hall
Dr. Barbara Anthony-Twarog
*LOCAL PUBLIC OBSERVING*

**Sunday, November 22**
8:00—9:30 PM
Prairie Park Nature Center

-President:
Rick Heschmeyer
rcjbm@sbcglobal.net

-Treasurer:
Dr. Steve Shawl
Shawl@ku.edu

-University Advisor:
Dr. Bruce Twarog
btwarog@ku.edu

-Webmaster:
Gary Webber
gwebber@ku.edu

**Observing Clubs**
Doug Fay
dfay@ku.edu

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**Report from the Officers:**
The October meeting focused on the origin and impact of energetic cosmic rays, a field of astrophysics that might become a future area of interest for Kansas and a different type of telescope. These exotic particles could originate near black holes at the center of active galaxies or could have a component linked to the physics of dark matter. Our public evening observing session and the special daytime solar session for the Fall ASTRONOMY DAY were cursed this month by cloudy skies that led to cancellations. Hopefully, the skies will be more cooperative for our next Sunday evening session on Nov. 22. If you can help in the evening or just want to bring a telescope out for a look at the sky, please join us around 8PM.

Our FRIDAY NOVEMBER 13 meeting will be the annual Cub Scout education (Continued on page 2)

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**Fermi Telescope Caps First Year With Glimpse of Space-Time**

Fermi Press Release

On May 10, 2009 a pair of gamma-ray photons reached the Fermi Gamma-Ray Space Telescope only 900 milliseconds apart after traveling for 7 billion years. Fermi's measurement gives us rare experimental evidence that space-time is smooth as Einstein predicted, and has shut the door on several approaches to gravity where space-time is foamy enough to interfere strongly with light.

During its first year of operations, NASA's Fermi Gamma Ray Space Telescope mapped the extreme sky with unprecedented resolution and sensitivity. It captured more than 1,000 discrete sources of gamma rays -- the highest-energy form of light. Capping these achievements was a measurement that provided rare experimental evidence about the very

(Continued on page 2)
In this illustration, one photon (purple) carries a million times the energy of another (yellow). Some theorists predict travel delays for higher-energy photons, which interact more strongly with the proposed frothy nature of space-time. Yet Fermi data on two photons from a gamma-ray burst fail to show this effect, eliminating some approaches to a new theory of gravity. The animation link below shows the delay scientists had expected to observe. Credit: NASA/Sonoma State University/Aurore Simonnet

About the Astronomy Associates of Lawrence

The club is open to all people interested in sharing their love for astronomy. Monthly meetings are typically on the second Fri-day of each month and often feature guest speakers, presentations by club members, and a chance to exchange amateur astronomy tips. Approximately the last Sunday of each month we have an open house at the Prairie Park Nature Center. Periodic star parties are scheduled as well. For more information, please contact the club officers: our president, Rick Heschmeyer at rcjbm@sbcglobal.net, our webmaster, Gary Webber, at gwebber@ku.edu, or our faculty advisor, Prof. Bruce Twarog at btwarog@ku.edu. Because of the flexibility of the schedule due to holidays and alternate events, it is always best to check the Web site for the exact Fridays and Sundays when events are scheduled. The information about AAL can be found at http://www.ku.edu/~aal.

Copies of the Celestial Mechanic can also be found on the web at http://www.ku.edu/~aal/celestialmechanic
CIRS," adds Spilker. "That's the challenge with CIRS. It's not like seeing a close-up picture of Mars, which can tell you something about its geology right away. We have to look at the CIRS data from different times and sun angles to see how the ring temperatures are changing, then make computer models to test our theories on what those temperatures say about the rings."

The effort to understand the rings could help us understand our origin. "Our solar system formed from a dusty disk, so by understanding the dynamics in a disk like Saturn's rings, we can gain insight into how Earth and the other planets in our solar system were made," said Spilker. The equators of both Earth and Saturn are tilted compared to their orbit around the sun. This tilt makes the sun appear to rise higher and lower in the sky throughout the year as Earth progresses in its orbit, causing the seasons to change. Likewise, Saturn's tilt makes the sun appear higher and lower in the sky as Saturn moves in its orbit, which takes about 29.5 years to complete.

Saturn experiences two equinoxes per orbit, just as Earth does, when the planet's equator lines up edge-on to its orbital plane, causing the sun to appear directly over the equator. For a viewer on Saturn, the sun would seem to move from south to north around the time of the August 11 equinox.

Technically, the equinox is the instant when the sun appears directly over the equator, but Saturn's situation gives the rings an extended twilight. Saturn is about 10 times farther from the sun than Earth. Since Saturn is farther from the Sun's gravitational pull, it moves relatively slowly in its orbit compared to Earth, which makes it take longer for the sun to noticeably appear higher or lower in the sky. Also, even as far away as Saturn, the sun is large enough to appear as a disk, not a point, according to Spilker.

So, before the August 11 equinox, a viewer embedded in Saturn's rings would have seen sunlight fade as the top edge of the solar disk appeared to touch the rings first. This would be followed by darkness around the equinox as the solar disk slowly crossed the ring plane. Full sunlight would have returned when the sun's bottom edge rose above the ring plane, about four days from when the sunlight first began to fade.

Blazars -- distant galaxies whose massive black holes emit fast-moving jets of matter toward us -- are by far the most prevalent source, now numbering more than 500. In our own galaxy, gamma ray sources include 46 pulsars and two binary systems where a neutron star rapidly orbits a hot, young star.

"The Fermi team did a great job commissioning the spacecraft and starting its science observations," said Jon Morse, Astrophysics Division director at NASA Headquarters in Washington. "And now Fermi is more than fulfilling its unique scientific promise for making novel, high-impact discoveries about the extreme universe and the fabric of space-time."
bolts of lightning spidering across the sky. Look away at the wrong time and (FLASH!) you miss it.

Lightning is much more than just a beautiful spectacle, though. It’s a window into the heart of the storm, and it could even provide clues about climate change. Strong vertical motions within a storm cloud help generate the electricity that powers lightning. These updrafts are caused when warm, moist air rises. Because warmth and lightning are inextricably connected, tracking long-term changes in lightning frequency could reveal the progress of climate change.

It’s one of many reasons why scientists want to keep an unwavering eye on lightning. The best way to do that? With a satellite 35,800 km overhead. At that altitude, satellites orbit at just the right speed to remain over one spot on the Earth’s surface while the planet rotates around its axis — a “geostationary” orbit. NASA and NOAA scientists are working on an advanced lightning sensor called the Geostationary Lightning Mapper (GLM) that will fly onboard the next generation geostationary operational environmental satellite, called GOES-R, slated to launch around 2015.

“GLM will give us a constant, eye-in-the-sky view of lightning over a wide portion of the Earth,” says Steven Goodman, NOAA chief scientist for GOES-R at NASA’s Goddard Space Flight Center. Once GLM sensors are flying on GOES-R and its sister GOES-S, that view will extend 18,000 km from New Zealand, east across the Pacific Ocean, across the Americas, and to Africa’s western coast.

With this hemisphere-scale view, scientists will gather an unprecedented amount of data on how lightning varies from place to place, year to year, and even decade to decade. Existing lightning sensors are either on the ground — which limits their geographic range — or on satellites that orbit much closer to Earth. These satellites circle the Earth every 90 minutes or so, quickly passing over any one area, which can leave some awkward gaps in the data.

Goodman explains: “Low-Earth orbit satellites observe a location such as Florida for only a minute at a time. Many of these storms occur in the late afternoon, and if the satellite’s not overhead at that time, you’re going to miss it.”

GLM, on the other hand, won’t miss a thing. Indeed, in just two weeks of observations, GLM is expected gather more data than NASA’s two low-Earth orbiting research sensors did in 10+ years. The new data will have many uses beyond understanding climate change. For example, wherever lightning flashes are abundant, scientists can warn aircraft pilots of strong turbulence. The data may also offer new insights into the evolution of storms and prompt improvements in severe weather forecasting.

Staring at (FLASH!) Did you miss another one? The time has come for GLM. Want to know how to build a weather satellite? Check the “how to” booklet at scijinks.gov/weather/technology/build_satellite.

This article was provided by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.
The most distant galaxy cluster yet has been discovered by combining data from NASA's Chandra X-ray Observatory and optical and infrared telescopes. The cluster is located about 10.2 billion light years away, and is observed as it was when the Universe was only about a quarter of its present age.

The galaxy cluster, known as JKCS041, beats the previous record holder by about a billion light years. Galaxy clusters are the largest gravitationally bound objects in the Universe. Finding such a large structure at this very early epoch can reveal important information about how the Universe evolved at this crucial stage.

JKCS041 is found at the cusp of when scientists think galaxy clusters can exist in the early Universe based on how long it should take for them to assemble. Therefore, studying its characteristics - such as composition, mass, and temperature - will reveal more about how the Universe took shape.

"This object is close to the distance limit expected for a galaxy cluster," said Stefano Andreaon of the National Institute for Astrophysics (INAF) in Milan, Italy. "We don't think gravity can work fast enough to make galaxy clusters much earlier."

Distant galaxy clusters are often detected first with optical and infrared observations that reveal their component galaxies dominated by old, red stars. JKCS041 was originally detected in 2006 in a survey from the United Kingdom Infrared Telescope (UKIRT). The distance to the cluster was then determined from optical and infrared observations from UKIRT, the Canada-France-Hawaii telescope in Hawaii and NASA's Spitzer Space Telescope. Infrared observations are important because the optical light from the galaxies at large distances is shifted into infrared wavelengths because of the expansion of the universe.

The Chandra data were the final - but crucial - piece of evidence as they showed that JKCS041 was, indeed, a genuine galaxy cluster. The extended X-ray emission seen by Chandra shows that hot gas has been detected between the galaxies, as expected for a true galaxy cluster rather than one that has been caught in the act of forming.

Also, without the X-ray observations, the possibility remained that this object could have been a blend of different groups of galaxies along the line of sight, or a filament, a long stream of galaxies and gas, viewed front on. The mass and temperature of the hot gas detected estimated from the Chandra observations rule out both of those alternatives.

The extent and shape of the X-ray emission, along with the lack of a central radio source argue against the possibility that the X-ray emission is caused by scattering of cosmic microwave background light by particles emitting radio waves.

It is not yet possible, with the detection of just one extremely distant galaxy cluster, to test cosmological models, but searches are underway to find other galaxy clusters at extreme distances.

"This discovery is exciting because it is like finding a Tyrannosaurus Rex fossil that is much older than any other known," said co-author Ben Maughan, from the University of Bristol in the United Kingdom. "One fossil might just fit in with our understanding of dinosaurs, but if you found many more, you would have to start rethinking how dinosaurs evolved. The same is true for galaxy clusters and our understanding of cosmology."

The previous record holder for a galaxy cluster was 9.2 billion light years away, XMMXCS J2215.9-1738, discovered by ESA's XMM-Newton in 2006. This broke the previous distance record by only about 0.1 billion light years, while JKCS041 surpasses XMMXCS J2215.9 by about ten times that. "What's exciting about this discovery is the astrophysics that can be done with detailed follow-up studies," said Andreaon.
A Long Night Falls Over Saturn's Rings
NASA Press Release

As Saturn's rings orbit the planet, a section is typically in the planet's shadow, experiencing a brief night lasting from 6 to 14 hours. However, once approximately every 15 years, night falls over the entire visible ring system for about four days.

This happens during Saturn's equinox, when the sun is directly over Saturn's equator. At this time, the rings, which also orbit directly over the planet's equator, appear edge-on to the sun. During equinox, light from the sun hits the ring particles at very low angles, accenting their topography and giving us a three-dimensional view of the rings. "The equinox is a very special geometry, where the sun is turned off as far as the rings themselves are concerned, and all energy comes from Saturn," said Dr. Michael Flasar of NASA's Goddard Space Flight Center in Greenbelt, Md.

During Saturn's latest equinox August 11, the rings reached a temperature of 382 degrees below zero Fahrenheit, the coldest yet observed, as seen by the Composite Infrared Spectrometer (CIRS) instrument on board the Cassini spacecraft in orbit around Saturn. CIRS was developed at NASA Goddard, and Flasar is the Principal Investigator for the instrument.

"The whole point of the CIRS observations of Saturn's rings, other than producing some cool pictures, is to learn something about the physical properties of the ring particles: their spin rates, how sluggish they are in storing and radiating heat (a diagnostic of size and composition), and their vertical distribution in the ring 'plane'," said Flasar. Although the rings are thousands of miles wide, they are only about 30 feet thick. They are made of particles that are mostly water-ice. Scientists continue to debate the rings' origin and age. Some think they could be remnants of a shattered moon or captured comets, while others think they could have formed along with Saturn from the primordial disk of gas and dust that gave birth to our solar system.

"At first glance, Saturn's rings look broad and bland, but then we got close-up images from the Voyager flybys, and our reaction was: oh, my gosh, there's structure everywhere -- what's going on?" said Dr. Linda Spilker, of NASA's Jet Propulsion Laboratory (JPL), Pasadena, Calif. Researchers have discovered that while most of the ring particles are as small as dust and pebbles, there are a few chunks as big as mountains, and even some small moons several miles across embedded in the rings. Instead of orderly orbiting around Saturn, the particles clump together and drift apart, and the rings ripple and warp under the gravitational influence of Saturn's swarm of more than 60 moons.

"The closer we look at the rings, the more complex they get," says Spilker, Deputy Project Scientist for the CASSINI mission and a Co-Investigator on CIRS. She is leading the instrument team's investigation of the rings.

"Because Saturn's rings are so extended, going out to more than twice Saturn's radius (from the cloud tops), the furthest rings get less heat from Saturn than the innermost rings, so the ring temperatures at equinox tend to fall off with distance from Saturn's center," said Flasar.

However, the CIRS team discovered that the A-ring -- the outermost of the wide, bright rings -- did not cool off as much as expected during the equinox. This might give clues about its structure and evolution. "One possibility is that the gravitational influence of moons outside the A-ring is stirring up waves in it," said Spilker. "These waves could be much higher than the typical thickness of the rings. Since the waves rise above the ring plane, material in the waves would still be exposed to sunlight during the equinox, which would warm up the A-ring more than expected."

"But we have to carefully test this idea with computer models to see if it produces the temperatures we observed with

(Continued on page 3)
Additionally, the exquisite precision of VLBI networks makes them sensitive to many kinds of disturbances, called noise. Differences in atmospheric pressure and humidity caused by weather systems, flexing of the Earth's crust due to tides, and shifting of antenna locations from plate tectonics and earthquakes all affect VLBI measurements. "A significant challenge was modeling all these disturbances in computers to take them into account and reduce the noise, or uncertainty, in our position observations," said Ma.

Another major source of noise is related to changes in the structure of the quasars themselves, which can be seen because of the extraordinary resolution of the VLBI networks, according to Ma. The ICRF maps are not only useful for navigation on Earth; they also help us find our way in space -- the ICRF grid and some of the objects themselves are used to assist spacecraft navigation for interplanetary missions, according to Ma. Despite its usefulness for things like GPS, the primary application for the ICRF maps is astronomy. Researchers use the ICRF maps as driving directions for telescopes. Objects are referenced with coordinates derived from the ICRF so that astronomers know where to find them in the sky.

Also, the optical light visible to our eyes is only a small part of the electromagnetic radiation produced by celestial objects, which ranges from less-energetic, low-frequency radiation, like radio and microwaves, through optical light to highly energetic, high-frequency radiation like X-rays and gamma-rays. Astronomers use special detectors to make images of objects producing radiation our eyes can't see. Even so, since things in space can have extremely different temperatures, objects that generate radiation in one frequency band, say optical, do not necessarily produce radiation in another, perhaps radio. The main scientific use of the ICRF maps is a precise grid for combining observations of objects taken using different frequencies and accurately locating them relative to each other in the sky.

Astronomers also use the frame as a backdrop to record the motion of celestial objects closer to us. Tracing how stars and other objects move provides clues to their origin and evolution. The next update to the ICRF may be done in space. The European Space Agency plans to launch a satellite called Gaia in 2012 that will observe about a half-million quasars. Gaia uses an optical telescope, but because it is above the atmosphere, the satellite will be able to clearly see these faint objects and precisely locate them in the sky. The mission will use quasars that are optically bright, many of which are too dim in radio to be useful for the VLBI networks. The project expects to have enough observations by 2018 to 2020 to produce the next-generation ICRF.

ICRF2 involved researchers from Australia, Austria, China, France, Germany, Italy, Russia, Ukraine, and the United States; and was funded by organizations from these countries, including NASA. The analysis efforts are coordinated by the IVS. The IAU officially adopts the ICRF maps and recommends their occasional updates.

show the precision of his observations revealing that Neptune would have looked just like a faint star almost exactly where Galileo observed it," Professor Jamieson says. But a planet is different to a star because planets orbit the Sun and move through the sky relative to the stars. It is remarkable that on the night of January 28 in 1613 Galileo noted that the "star" we now know is the planet Neptune appeared to have moved relative to an actual nearby star."

There is also a mysterious unlabeled black dot in his earlier observations of January 6, 1613, which is in the right position to be Neptune. "I believe this dot could reveal he went back in his notes to record where he saw Neptune earlier when it was even closer to Jupiter but had not previously attracted his attention because of its unremarkable star-like appearance. If the mysterious black dot on January 6 was actually recorded on January 28, Professor Jamieson proposes this would prove that Galileo believed he may have discovered a new planet."

By using the expertise of trace element analysts from the University of Florence, who have previously analyzed inks in Galileo's manuscripts, dating the unlabelled dot in his notebook may be possible. This analysis may be conducted in October this year. "Galileo may indeed have formed the hypothesis that he had seen a new planet which had moved right across the field of view during his observations of Jupiter over the month of January 1613," Professor Jamieson says. "If this is correct Galileo observed Neptune 234 years before its official discovery."

But there could be an even more interesting possibility still buried in Galileo's notes and letters. "Galileo was in the habit of sending a scrambled sentence, an anagram, to his colleagues to establish his priority for the sensational discoveries he made with his new telescope. He did this when he discovered the phases of Venus and the rings of Saturn. So perhaps somewhere he wrote an as-yet undecoded anagram that reveals he knew he discovered a new planet," Professor Jamieson speculates.

Professor Jamieson presented at the first of a series of lectures in July, aimed at giving an insight into fundamental questions in physics to celebrate the 2009 International Year of Astronomy.
Many of us have been rescued from unfamiliar territory by directions from a Global Positioning System (GPS) navigator. GPS satellites send signals to a receiver in your GPS navigator, which calculates your position based on the location of the satellites and your distance from them. The distance is determined by how long it took the signals from various satellites to reach your receiver. The system works well, and millions rely on it every day, but what tells the GPS satellites where they are in the first place?

"For GPS to work, the orbital position, or ephemeris, of the satellites has to be known very precisely," said Dr. Chopo Ma of NASA’s Goddard Space Flight Center in Greenbelt, Md. "In order to know where the satellites are, you have to know the orientation of the Earth very precisely."

This is not as obvious as simply looking at the Earth – space is not conveniently marked with lines to determine our planet's position. Even worse, "everything is always moving," says Ma. Earth wobbles as it rotates due to the gravitational pull (tides) from the moon and the sun. Even apparently minor things like shifts in air and ocean currents and motions in Earth's molten core all influence our planet's orientation. Just as you can use landmarks to find your place in a strange city, astronomers use landmarks in space to position the Earth. Stars seem the obvious candidate, and they were used throughout history to navigate on Earth. "However, for the extremely precise measurements needed for things like GPS, stars won't work, because they are moving too," says Ma.

What is needed are objects so remote that their motion is not detectable. Only a couple classes of objects fit the bill, because they also need to be bright enough to be seen over incredible distances. Things like quasars, which are typically brighter than a billion suns, can be used. Many scientists believe these objects are powered by giant black holes feeding on nearby gas. Gas trapped in the black hole’s powerful gravity is compressed and heated to millions of degrees, giving off intense light and/or radio energy.

Most quasars lurk in the outer reaches of the cosmos, over a billion light years away, and are therefore distant enough to appear stationary to us. For comparison, a light year, the distance light travels in a year, is almost six trillion miles. Our entire galaxy, consisting of hundreds of billions of stars, is about 100,000 light years across.

A collection of remote quasars, whose positions in the sky are precisely known, forms a map of celestial landmarks in which to orient the Earth. The first such map, called the International Celestial Reference Frame (ICRF), was completed in 1995. It was made over four years using painstaking analysis of observations on the positions of about 600 objects.

Ma led a three-year effort to update and improve the precision of the ICRF map by scientists affiliated with the International Very Long Baseline Interferometry Service for Geodesy and Astrometry (IVS) and the International Astronomical Union (IAU). Called ICRF2, it uses observations of approximately 3,000 quasars. It was officially recognized as the fundamental reference system for astronomy by the IAU in August, 2009.

Making such a map is not easy. Despite the brilliance of quasars, their extreme distance makes them too faint to be located accurately with a conventional telescope that uses optical light (the light that we can see). Instead, a special network of radio telescopes is used, called a Very Long Baseline Interferometer (VLBI). The larger the telescope, the better its ability to see fine detail, called spatial resolution. A VLBI network coordinates its observations to get the resolving power of a telescope as large as the network. VLBI networks have spanned continents and even entire hemispheres of the globe, giving the resolving power of a telescope thousands of miles in diameter. For ICRF2, the analysis of the VLBI observations reduced uncertainties in position to angles as small as 40 microarcseconds, about the thickness of a 0.7 millimeter mechanical pencil lead in Los Angeles when viewed from Washington. This minimum uncertainty is about five times better than the ICRF, according to Ma. These networks are arranged on a yearly basis as individual radio telescope stations commit time to make coordinated observations. Managing all these coordinated observations is a major effort by the IVS, according to Ma.

A sky map of the 295 defining sources of ICRF2. The dashed line represents the ecliptic and the solid line is the galactic plane. Credit: Dave Boboltz / USNO

(Continued on page 7)
Blast From The Past: Most Distant Stellar Object Gives Clues About Early Universe
Science Daily

Astronomers using the National Science Foundation's Very Large Array (VLA) radio telescope have gained tantalizing insights into the nature of the most distant object ever observed in the Universe -- a gigantic stellar explosion known as a Gamma Ray Burst (GRB).

The explosion was detected on April 23 by NASA's Swift satellite, and scientists soon realized that it was more than 13 billion light-years from Earth. It represents an event that occurred 630 million years after the Big Bang, when the Universe was only four percent of its current age of 13.7 billion years.

"This explosion provides an unprecedented look at an era when the Universe was very young and also was undergoing drastic changes. The primal cosmic darkness was being pierced by the light of the first stars and the first galaxies were beginning to form. The star that exploded in this event was a member of one of these earliest generations of stars," said Dale Frail of the National Radio Astronomy Observatory.

Astronomers turned telescopes from around the world to study the blast, dubbed GRB 090423. The VLA first looked for the object the day after the discovery, detected the first radio waves from the blast a week later, then recorded changes in the object until it faded from view more than two months later.

"It's important to study these explosions with many kinds of telescopes. Our research team combined data from the VLA with data from X-ray and infrared telescopes to piece together some of the physical conditions of the blast," said Derek Fox of Pennsylvania State University. "The result is a unique look into the very early Universe that we couldn't have gotten any other way," he added.

The scientists concluded that the explosion was more energetic than most GRBs, was a nearly-spherical blast, and that it expanded into a tenuous and relatively uniform gaseous medium surrounding the star.

Astronomers suspect that the very first stars in the Universe were very different -- brighter, hotter, and more massive -- from those that formed later. They hope to find evidence for these giants by observing objects as distant as GRB 090423 or more distant.

"The best way to distinguish these distant, early-generation stars is by studying their explosive deaths, as supernovae or Gamma Ray Bursts," said Poonam Chandra, of the Royal Military College of Canada, and leader of the research team. While the data on GRB 090423 don't indicate that it resulted from the death of such a monster star, new astronomical tools are coming that may reveal them.

"The Atacama Large Millimeter/submillimeter Array (ALMA), will allow us to pick out these very-distant GRBs more easily so we can target them for intense followup observations. The Expanded Very Large Array, with much greater sensitivity than the current VLA, will let us follow these blasts much longer and learn much more about their energies and environments. We'll be able to look back even further in time," Frail said. Both ALMA and the EVLA are scheduled for completion in 2012.

Galileo's Notebooks May Reveal Secrets Of New Planet
Science Daily

Galileo knew he had discovered a new planet in 1613, 234 years before its official discovery date, according to a new theory by a University of Melbourne physicist. Professor David Jamieson, Head of the School of Physics, is investigating the notebooks of Galileo from 400 years ago and believes that buried in the notations is the evidence that he discovered a new planet that we now know as Neptune.

A hypothesis of how to look for this evidence has been published in the journal Australian Physics and was presented at the first lecture in the 2009 July Lectures in Physics program at the University of Melbourne in the beginning of July. If correct, the discovery would be the first new planet identified by humanity since deep antiquity. Galileo was observing the moons of Jupiter in the years 1612 and 1613 and recorded his observations in his notebooks. Over several nights he also recorded the position of a nearby star which does not appear in any modern star catalogue.

"It has been known for several decades that this unknown star was actually the planet Neptune. Computer simulations