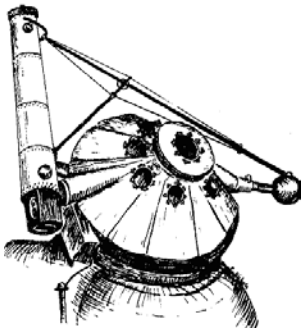
THE SPRINGFIELD TELESCOPE MAKERS &
THE HARTNESS HOUSE INN *presents*

Innovation in Astronomy Education & Outreach

The Hartness House Workshop

August 13, 2015

Welcome to the Hartness House Workshop 2015



Hartness House Workshop August 13, 2015
Innovation in Astronomy Education & Outreach

8:30 – 9:00 **Registration and Coffee**
Host Dan Lorraine, Seagrave Memorial Observatory, Skyscrapers, Inc.

9:00 – 9:05 **Words of Welcome**
David Tabor, President, Springfield Telescope Makers

9:05 – 9:10 **Introduction**
John W. Briggs, Workshop Papers Chair

9:10 – 9:25 **Stellafane as a Grand Experiment in Astronomical Education**
John W. Briggs, FOAH Observatory, Magdalena, New Mexico

9:25 – 9:40 **Planting Astronomical Seeds on Breezy Hill**
Professor Kristine Larsen, Central Connecticut State University

9:40 – 10:10 **Sidewalk Astronomy at the Smithsonian's Phoebe Waterman Haas Public Observatory**
Shauna Edson, Astronomy Educator, Smithsonian National Air and Space Museum, Washington, DC

10:10 – 10:30 **Coffee Break**

10:30 – 11:00 **Establishing the Jordan Observatory and Emera Astronomy Center as Research and Education Tools at the University of Maine**
Scott Mitchell, Acting Director, Emera Astronomy Center, Orono, Maine

11:30 – 12:00 **Outreach and Research Education at the Northern Skies Observatory of the Northeast Kingdom Astronomy Foundation**
Brad P. Vietje, NKAF, Peacham, Vermont, and William Vinton, NKAF and St. Johnsbury Academy, St. Johnsbury, Vermont

12:00 – 12:45 **Lunch**

12:45 – 1:30 **Open House at the Hartness-Porter Museum of Telescope Making**
Berton C. Willard, Museum Curator, Springfield Telescope Makers

1:30 – 2:00 **The Land of Enchantment and Astronomy Outreach**
Dr. Daniel A. Klinglesmith III, Research Scientist, Magdalena Ridge Observatory, New Mexico Institute of Mining and Technology, and Judith Stanley, Public Information Officer, National Astronomical Radio Observatory

2:00 – 2:30 **Research Based Astronomy Education**
John Blackwell, Science Chair and Director, Grainger Observatory, Phillips Exeter Academy, Exeter, New Hampshire

2:30 – 3:00 **Coffee Break**

3:00 – 3:30 **Research Astronomy at Phillips Academy**
Caroline E. Odden, Director, Phillips Academy Observatory, Andover, Massachusetts

3:30 – 4:00 **Hands-on Astrophysics at Mount Wilson: "Combating Nintendo Astronomy"**
Professor Paula Turner, Kenyon College; Director, CUREA Program, Mount Wilson Observatory

4:00 – 4:30 **The Summer Science Program: How High School Students Might Save Us from a Killer Asteroid, or at Least Have Fun Trying**
Dr. Michael Faison, Director, Leitner Family Observatory, Yale University

4:30 – 5:15 **Break and Poster Presentation**
Engaging the Public in Nature and Astronomy Education: A Joint Program with the Appalachian Mountain Club
Dr. Douglas Arion, Director Carthage Institute of Astronomy

5:15 – 6:15 **Cocktail Hour at the Telescope Tavern, Hartness House Inn**
Fruit and Cheese hosted by the Antique Telescope Society

6:15 – 7:15 **Banquet at Hartness House Inn**

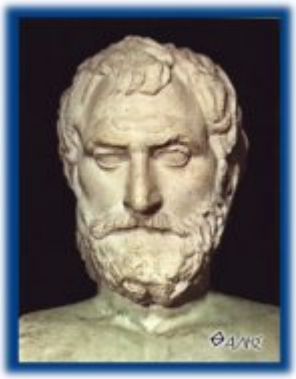
7:15 – 8:00 **Observations and Updates on the State of Educational and Public Outreach for the 2017 Total Solar Eclipse**
Charles N. Fulco, Director of Space & Environmental Sciences, Port Chester Public Schools, New York

8:00 – 8:30 **Break**

8:30 PM **Evening Open House at Hartness Observatory**

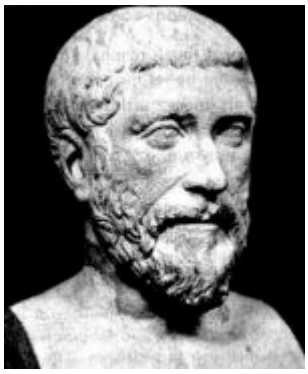
Weather permitting, this event will include evening observing and will be open to workshop participants, members of the Springfield Telescope Makers, and guests. Our hosts are Berton C. Willard, Curator of the Hartness-Porter Museum of Amateur Telescope Making, and David M. Groski from the Springfield Telescope Makers.

Great Astronomers



Thales (624-547 B.C., Ionian) was a Greek philosopher who traveled widely in Mesopotamia and Egypt, and brought astronomical records from these cultures back to Greece. He believed that the Earth is a disk floating on an endless ocean. Legend has it that he correctly predicted a solar eclipse in the year 585 B.C.

Anaximander (611-547 B.C., Ionian) was a Greek philosopher who made the first detailed maps of the Earth and the sky. He knew that the Earth was round, and believed that it was free-floating and unsupported. He measured its circumference, and was the first to put forward the idea that celestial bodies make full circles in their orbits. One of his greatest contributions was the fact that he was the first to conceptualize space as having depth.



Pythagoras (569-475 B.C., Ionian) was a mathematician who put forward the idea that the universe is made of crystal spheres that encircle the Earth. According to him, the Sun, the Moon, the planets, and the stars travel in separate spheres. When the spheres touch each other, a 'music of the spheres' can be heard.

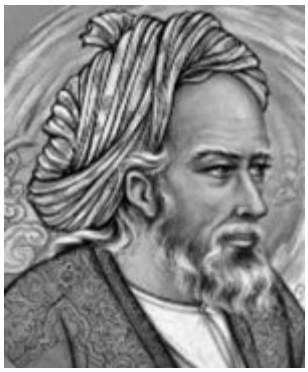
Aristotle (384-322 B.C., Greek), the great philosopher, proved that the Earth is spherical, and believed that it was at the center of the universe. His reason for believing this was actually quite scientific: he knew that if the Earth revolved around the Sun, then we should see the stars shift position throughout the year. Since he did not have the technology to detect this shift, as we do today, he concluded that Earth must rest at the center of the universe. According to him, the Sun, planets, and stars were located in spheres that revolved around the Earth.

Aristarchus (310-230 B.C., Greek) was the first to put forward the idea that the Sun was actually in the center of the universe. His theory was considered far too radical. Unfortunately, history tends to forget that he came to this conclusion about 1,750 years before Copernicus did! He also attempted to measure the relative distances between the Earth and the Sun and the Earth and the Moon. Even though he used a reasonable method, his results were not very accurate, because he lacked the technological equipment to make a precise measurement.

Hipparchus (190-120 B.C., Greek) is widely considered to be the greatest astronomer of ancient times. He compiled the first known star catalog to organize astronomical objects, and also came up with a scale to define the brightnesses of stars. A version of this magnitude system is still used today. He measured the distance from the Earth to the Moon to be 29.5 Earth diameters (we know today that the real value is 30 Earth diameters). Perhaps his greatest discovery was the precession, or wobble, of the Earth's axis, which is caused by the gravitational pull of the Sun and Moon.

Claudius Ptolemy (85-165 A.D., Greek) was an astronomer who used Hipparchus' extensive observations to develop a model that predicted the movements of the Sun, Moon, planets, and stars. His model, called the Ptolemaic system, visualized an Earth-centered universe and assumed that all astronomical objects move at constant speeds in circular orbits. The circle was considered by the ancients to be the perfect shape, and regardless of the evidence against circular orbits, Ptolemy built his model to fit this idea. The Ptolemaic model is one of the longest upheld scientific theories in history: it was the cornerstone of astronomy for 1,500 years.

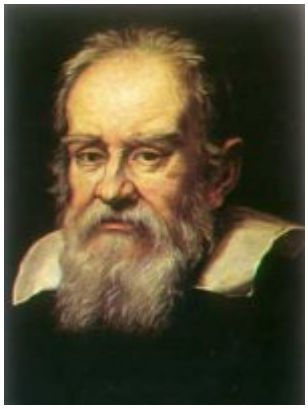
al-Khwarizmi (780-850, Islamic) was the inventor of algebra. He developed this mathematical device completely in words, not mathematical expressions, but based the system on the Indian numbers borrowed by the Arabs (what we today call Arabic numerals). His work was translated into Latin hundreds of years later, and served as the European introduction to the Indian number system, complete with its concept of zero. Al-Khwarizmi performed detailed calculations of the positions of the Sun, Moon, and planets, and did a number of eclipse calculations. He constructed a table of the latitudes and longitudes of 2,402 cities and landmarks, forming the basis of an early world map.



Omar Khayyam (1048-1131, Persian) was a great scientist, philosopher, and poet. He compiled many astronomical tables and performed a reformation of the calendar which was more accurate than the Julian and came close to the Gregorian. An amazing feat was his calculation of the year to be 365.24219858156 days long, which is accurate to the sixth decimal place!

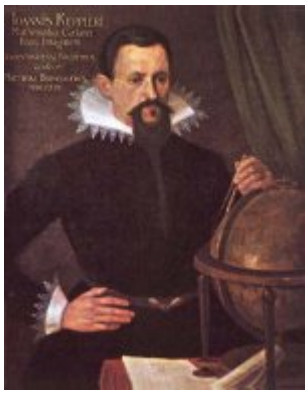
Nicolaus Copernicus (1473-1543, Polish) began a new era of astronomy when he concluded that the Sun was the center of the universe instead of the Earth. Copernicus felt that the Ptolemaic system was contrived, but in his revisions of that model, he kept the orbits circular. The revolutionary idea was not popular with the Church, but several other astronomers such as Brahe and Galileo helped to eventually prove that this model of the universe more accurately portrayed reality.

Tycho Brahe (1546-1601, Danish) built an observatory from which he made the most accurate astronomical observations up to that time. His observatory contained sophisticated equipment for mapping star positions, and for more than 20 years he made detailed records of his findings. He believed that the universe was a blend of the Ptolemaic and Copernican models, and created his own model in which the planets orbit the Sun and the Sun orbits the Earth.



Galileo Galilei (1564-1642, Italian) is the father of observational astronomy. In 1609, he heard about the Dutch invention of the telescope, and built one for himself. Even though his telescope was not very powerful compared to the amateur equipment available today, he was able to make a number of stunning discoveries which changed the face of astronomy. He saw the craters, mountains, and valleys of the Moon, noticed the huge number of stars making up the Milky Way, kept precise records of sunspot activity and the phases of Venus, and discovered four moons orbiting Jupiter. These moons are still called the Galilean Moons today, in honor of the earth-shattering scientific effects of the discovery. During a time when the Earth was still considered to be at the center of the universe, he publicized the fact that other astronomical bodies, such as Jupiter's moons, were clearly revolving around something other than the Earth. Galileo's support of the Copernican model of the universe frightened the Church, which put Galileo on trial in 1633. He was forced to renounce his Copernican views and was

held under house arrest for the rest of his life.



Johannes Kepler (1571-1630, German) was Tycho Brahe's assistant and student. He inherited his teacher's extensive collection of astronomical records, and used them to develop three laws of planetary motion. He believed in the Copernican model of the universe, although he found it difficult to fit Tycho's observations of Mars into the model with a circular orbit. He therefore used the idea of elliptical orbits to describe the motions of the planets, which became known as Kepler's first law. His second law states that a line from the Sun to a planet sweeps out equal areas in equal amounts of time. The third law was a masterpiece of simplicity: the square of the number of years of a planet's orbital period is equal to the cube of that planet's average distance from the Sun.

Giovanni Cassini (1625-1712, Italian) was the astronomer who first discovered the division in the rings of Saturn, today known as the Cassini division. He also found four moons orbiting Saturn, and measured the periods of rotation of Mars and Jupiter. The Cassini space mission currently on its way to Saturn was named after him.

Isaac Newton (1643-1727, British) was a mathematician who developed extensive mathematics to describe the astronomical models of Copernicus and Kepler. His Theory of Universal Gravitation was the foundation of Kepler's laws of planetary motion, but it also went further: Newton showed that the laws governing astronomical bodies were the same laws governing motion on the surface of the Earth. Newton's scientific ideas are so complete that they still offer an accurate description of physics today, except for certain cases in which 20th century physics must be used.

Edmond Halley (1656-1742, British) became famous for predicting the 1682 appearance of a comet called Halley's Comet. He proved that the orbit of comets is periodic.

Charles Messier (1730-1817, French) was a comet-hunter who published a list of 110 astronomical objects that should not be mistaken for comets. This list includes some of the most intriguing sights visible through small telescopes, including galaxies, nebulae, and star clusters. The M objects, as they are now called, are used today to identify the most brilliant objects in the sky.

William Herschel (1738-1822, British) was the discover of Uranus and two of its moons. He also discovered two more moons of Saturn and several asteroids, and made a catalog of 2,500 astronomical objects. He found the polar ice caps on Mars, which are today being studied by several satellites in the hopes of shedding light on the existence of water on Mars.

Johann Bode (1747-1826, German) published a law now known as Bode's Law, which predicts mathematically the distances of the planets from the Sun. Using his law, he was able to determine that there should mathematically be another planet between Mars and Jupiter; this is where the asteroid belt is located.

Joseph von Fraunhofer (1787-1826, German) discovered dark lines in the spectrum coming from the Sun. He carefully measured the positions of over 300 of these lines, creating a wavelength standard that is still in use today.

Joseph Lockyer (1836-1920, British) was the astronomer who first discovered the element Helium when he was studying the Sun's atmosphere. He made detailed records of sunspot activity and also studied solar flares and prominences. He conducted several tours to places where solar eclipses would be visible. He was also one of the first archaeoastronomers: he wrote a wonderful book called 'The Dawn of Astronomy', which investigates the astronomy of ancient cultures, in particular Egypt.

Annie Jump Cannon (1863-1941, American) was a member of the famous group of Harvard astronomers called 'Pickering's Women'. The director of the Harvard College Observatory, Edward Pickering, hired a number of women to sort through and organize mounds of data on the stellar classification of stars. The stars were classified by their spectra, and Annie Cannon was the most prolific and careful of the workers. She single-handedly classified 400,000 stars into the scheme we use today (O B A F G K M), and discovered 300 variable stars. She paved the way for women entering the astronomical field.

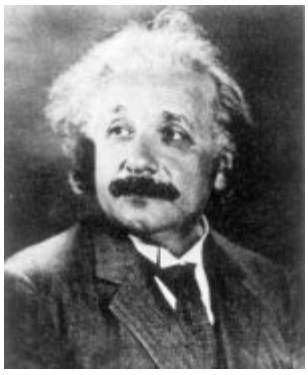
George Hale (1868-1938, American) discovered that sunspots have localized magnetic fields, which helped to explain an important phenomenon present in the Sun. Perhaps his greatest legacy was to found three important observatories: Yerkes, Mt. Wilson, and Palomar.

Henrietta Swan Levitt (1868-1921, American) was also a member of 'Pickering's Women' (see Annie Jump Cannon above). She discovered that a particular type of variable star known as a Cepheid could be used as a distance marker, making it possible to determine astronomical distances to objects.

Ejnar Hertzsprung (1873-1967, Danish) was one of the inventors of the Hertzsprung-Russell diagram, which shows the relationship between the absolute magnitude and the spectral type of stars. He also made the contribution of finding the distance to the Small Magellanic Cloud, a galaxy visible from Earth's southern hemisphere.

Karl Schwarzschild (1873-1916, German) was the first to study the theory of black holes. The Schwarzschild radius is the distance from a black hole at which bodies would have an escape velocity exceeding the speed of light and therefore would be invisible. He also wrote extensively on the curvature of space, based on Einstein's Theory of Relativity.

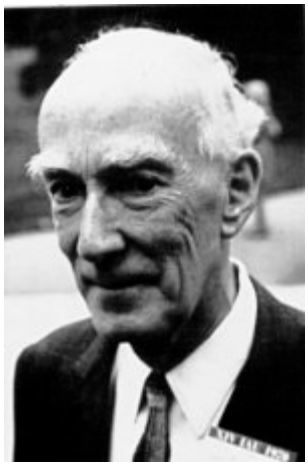
Henry Russell (1877-1957, American) was the one inventor of the Hertzsprung-Russell diagram describing the spectral types of stars. He measured the parallax of the stars photographically, allowing them to be properly placed on the H-R diagram.



Albert Einstein (1879-1955, German) was probably the greatest mind of the twentieth century. His Special Theory of Relativity, proposed in 1905, extended Newtonian Mechanics to very large speeds close to the speed of light. It describes the changes in measurements of physical phenomena when viewed by observers who are in motion relative to the phenomena. In 1915, Einstein extended this further in the General Theory of Relativity, which includes the effects of gravitation. According to this theory, mass and energy determine the geometry of spacetime, and curvatures of spacetime manifest themselves in gravitational forces.

Arthur Eddington (1882-1944, British) proved observationally that Einstein's prediction of light bending near the extreme mass of a star is scientifically accurate. He also explained the behavior of Cepheid variables, and discovered the relationship between the mass of a star and its luminosity.

Edwin Hubble (1889-1953, American) made an incredible contribution to astronomy and cosmology when he discovered that faraway galaxies are moving away from us. Known as Hubble's Law, the theory states that galaxies recede from each other at a rate proportional to their distance from each other. This concept is a cornerstone of the Big Bang model of the universe.



Jan Oort (1900-1992, Dutch) first measured the distance between our solar system and the center of the Milky Way Galaxy and calculated the mass of the Milky Way. An enormous contribution of his was the proposal of a large number of icy comets left over from the formation of the solar system, now known as the Oort Cloud.

George Gamow (1904-1968, Russian-born American) was the first to put forward the idea that solar energy comes from the process of nuclear fusion.

Karl Jansky (1905-1950, American) discovered that radio waves are emanating from space, which led to the science of radio astronomy.

Gerard Kuiper (1905-1973, Dutch-born American) discovered a large number of comets at the edge of the solar system beyond Pluto's orbit, known as the Kuiper belt. He also discovered several moons in the outer solar system and the atmosphere of Saturn's moon Titan.

Clyde Tombaugh (1906-1997, American) was the discoverer of the final planet in our solar system, Pluto. He found it photographically in 1930, using the telescope at the Lowell Observatory in Arizona.

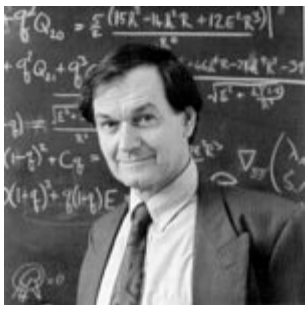
Subramanyan Chandrasekhar (1910-1995, Indian-born American) made important contributions to the theory of stellar evolution. He found that the limit, now called the Chandrasekhar limit, to the stability of white dwarf stars is 1.4 solar masses: any star larger than this cannot be stable as a white dwarf.

James Van Allen (1914-, American) discovered the magnetosphere of the Earth. The belts of radiation surrounding the planet are called the Van Allen belts, and moderate the amount of solar radiation hitting Earth.

Fred Hoyle (1915-2001, British) was a believer in the steady-state model of the universe, and thus did not believe in the Big Bang Theory. He was, however, the one who coined the term 'Big Bang'. He also believed that early life forms are transported by comets, and that the interaction of a comet with the Earth is how life appeared on our planet.

Robert Dicke (1916-1997, American) believed that it was possible to detect radiation left over from the Big Bang. He invented the microwave radiometer to detect this radiation, which has a wavelength of one centimeter.

Alan Sandage (1926-, American) calculated the ages of many globular clusters, and discovered the first quasar.



Roger Penrose (1931-, British) expanded the physics of black holes by showing that singularities in space were responsible for their existence.

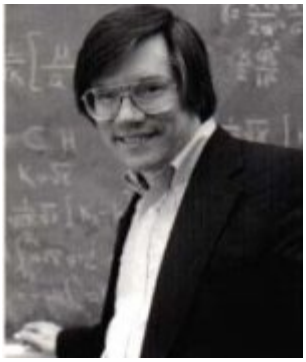
Arno Penzias (1933-, German-born American) was a co-discoverer of the cosmic microwave background radiation, which is radiation left over from the Big Bang.

Carl Sagan (1934-1996, American) could be called 'the astronomer of the people'. He popularized the science of astronomy with the general public, and revolutionized science fiction by believing that we are not alone in the universe. He championed the search for extraterrestrial intelligence, which continues today with a number of missions to Mars to search for signs of life on that planet.

Robert Wilson (1936-, American) was a co-discoverer of cosmic microwave background radiation left over from the Big Bang.

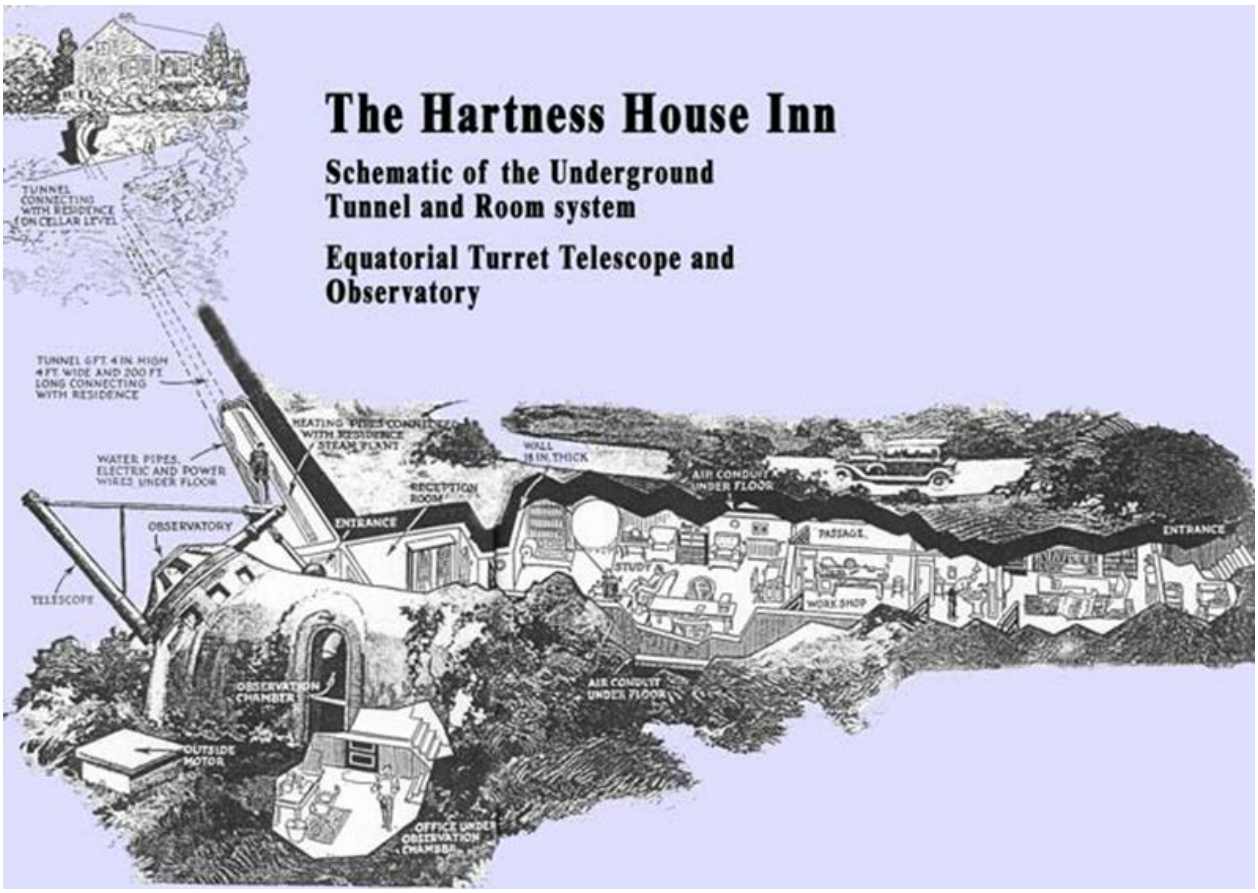
Kip Thorne (1940-, American) contributed to the understanding of black holes.

Stephen Hawking (1942-, British) is another brilliant mind of the twentieth century. He combined the theory of general relativity and quantum theory in order to prove that black holes emit radiation and eventually evaporate. Despite being completely immobile as a result of Lou Gehrig's disease, he has written numerous books to bring astronomy, physics, math, and cosmology to the general public.



Alan Guth (1940-, American) developed a new theory called the inflationary universe as an addition to the Big Bang Model. Inflation theory predicts that the universe

GREAT ASTRONOMERS from the Star Teach Astronomy Education website



We'll see you in 2016

John W. Briggs
Dan Lorraine

1926 the very first Stellafane
Porter & Ingalls far right