

Sputnik to SpaceX

Space exploration began on October 4, 1957. The Voyager 1 spacecraft is now more than 150 times farther from the Sun than the Earth. Every major planet and several Dwarf Planets have been explored by interplanetary probes.





Photo: Tim Knauer (1987)

Ancient Monuments, Ancient Observatories

Ancient structures such as Stonehenge have a clear astronomical link. The stones have sight lines that mark where the Sun rises and sets at the solstices. However, moving 45-ton stones 15 miles seems like a lot of effort to build a calendar. Did it have other uses? Various attributes have been ascribed to these constructs, some of them very unlikely. We'll visit places such as the Pyramid of the Sun and Chaco Canyon to investigate their astronomical attributes.



Analyzing Starlight – Build Your Own Spectroscope

Spectroscopes. Is there nothing they cannot do?

- Gustav Kirchhoff's spectroscope identified elements previously unknown on Earth.
- Pierre Janssen discovered a new element in the solar spectrum and named it *helium*.
- Cecilia Payne-Gaposchkin's spectroscope showed that stars were made of hydrogen and helium.
- Edwin Hubble's spectroscope told him that the universe was expanding.
- The spectroscope of Mayor & Queloz found the first exoplanet around a Sun-like star.

The spectroscope offered and fulfilled on the promise to decode messages from the stars without having to visit them.

A raindrop is a crude spectroscope. You can build a much better one from items you likely already have at home.



Origin of the Solar System

The Solar System is 4.55 billion years old and has another ~ 4 billion years ahead of it.
Where did all of this *stuff* come from?



***Eta Carinae: A Star With a Past
...and No Future***

Eta Carinae is too far south to be observed north of Cairo, Egypt, making it unobservable to astronomers before the renaissance. It was recorded by some early southern explorers, including Edmund Halley and John Herschel. In the 1840's, it increased its luminosity by 10x. At its peak, it radiated energy at a rate 20 million times the Sun's. Modern instrumentation have revealed much that was hidden and presented more mysteries. One thing is certain: at only three *million* years old, *Eta's* life is nearly over.

Powers of Ten in Time

Through accidents of history, the *second* is our official unit of time. It's a convenient measure for human beings. Many things happen on the scale of a second: the time between human heartbeats and the time for the core of a giant star to collapse, for example. Events that happen faster than about 10 per second blur together in human perception. To describe events in the cosmos require vastly different time scales. The age of the universe is $\sim 10^{17}$ sec. An electron circles a hydrogen atom in $\sim 10^{-16}$ sec. In between is the observable universe.



Galaxies NGC 4038/4039 in mid-collision. It will require $>10^{16}$ sec to complete.

Image Credit: NASA, ESA, Hubble, HLA; Processing & Copyright: Domingo Pestana

The Greatest Astronomical Images

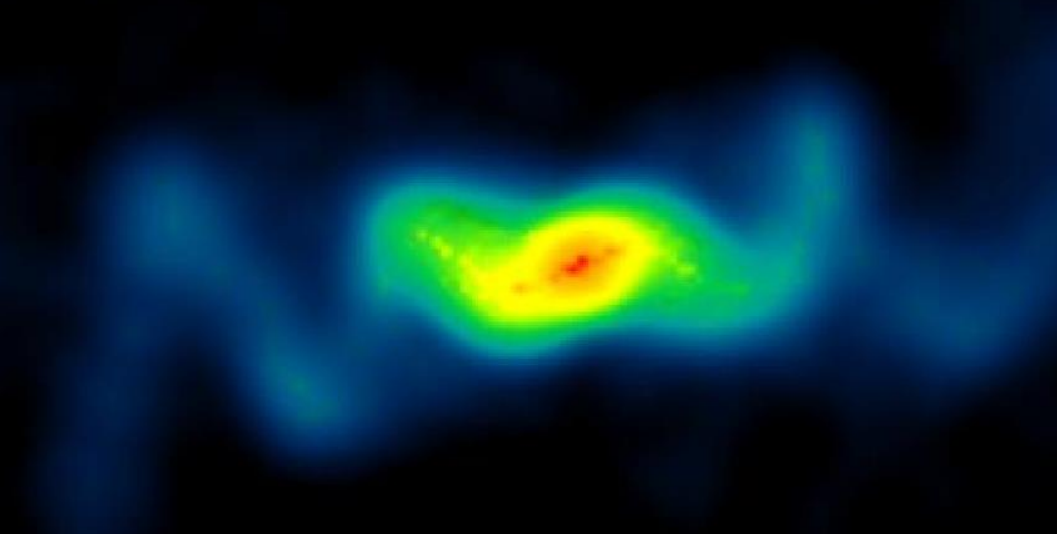
What makes a great astro-image?
Aesthetics alone? Importance to science? Technically challenging?
Must it be a photograph? In a thoroughly subjective process, we'll evaluate and admire outstanding images important to our understanding of the universe.





Clocks and Calendars

The measurement of time has always depended on our understanding of nature. Within a single human lifetime, we have gone from using the rotation of the Earth to fountains of falling atoms to measure time. How convenient it would be if there were exactly, say, 360 days in a year instead of 365.242189 days. How simple, and boring, the calendar would be with 30 days in every month.



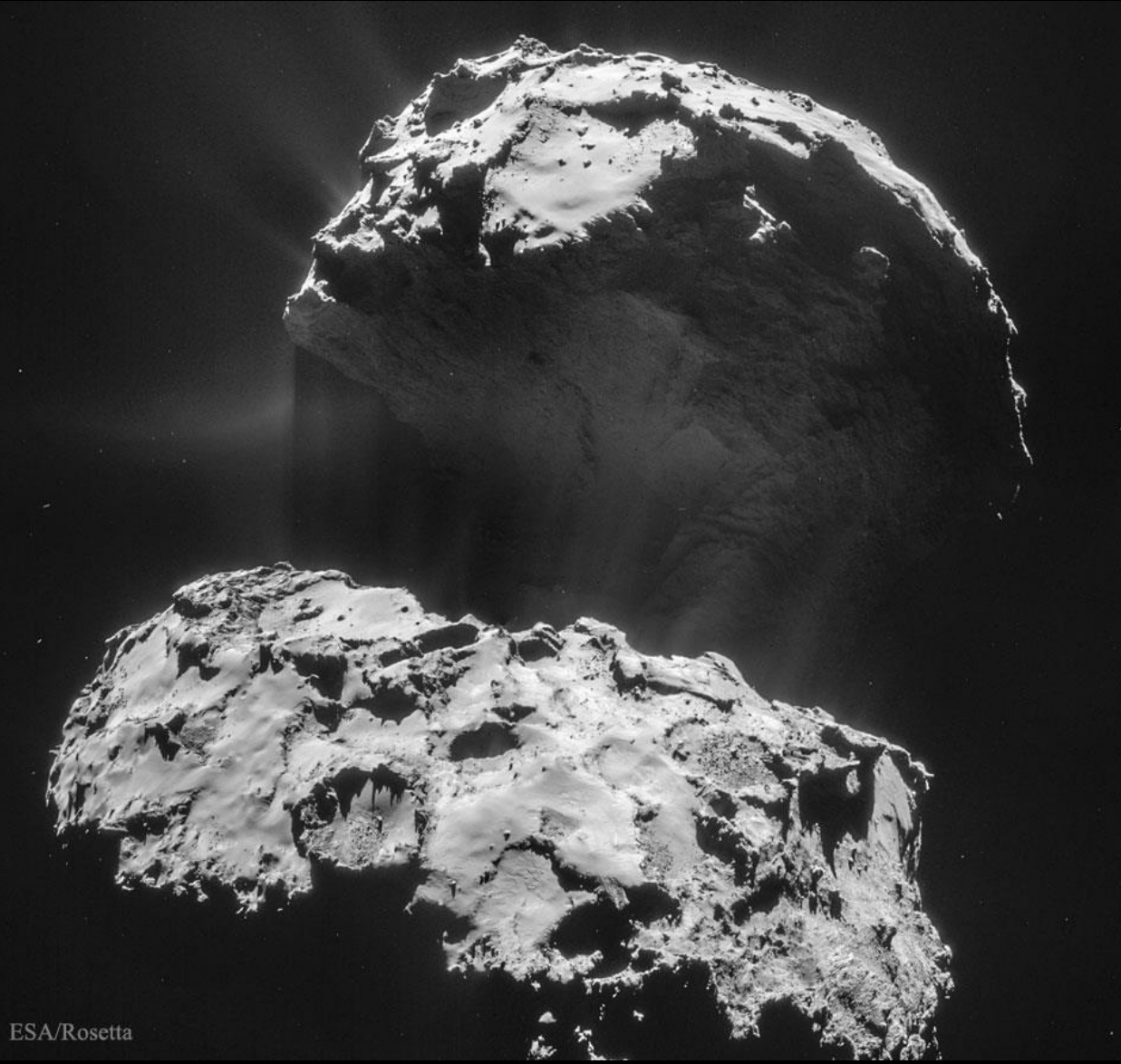
SS433: A Cosmic Sprinkler

Astronomers Stephenson and Sanduleak created a catalog of stars with unusual optical properties. The 433rd entry became famous when radio telescopes revealed that the star was set within a cloud of expanding gas. Were they related, or was it a chance alignment?

Deeper, and more frequent, observations with the highest resolutions available to radio astronomers, revealed a close binary system in which a black hole is siphoning gas from another star. The result is less a sprinkler than a blowtorch drilling into its surroundings. SS 433 is one of the possible outcomes of an exploding star.

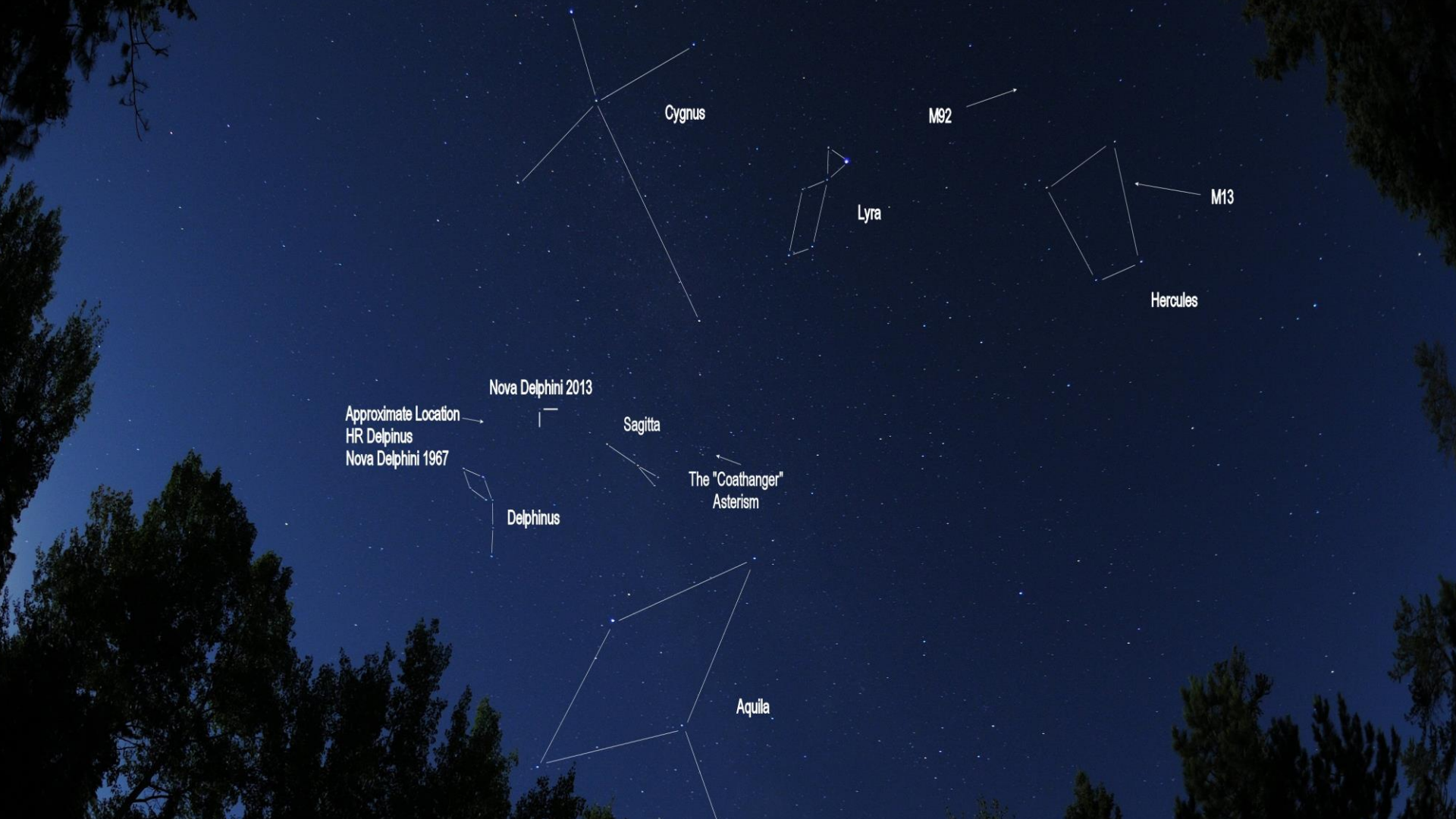
Rosetta at Comet 67/P: Thereby Hangs a Tail

The Rosetta spacecraft was launched by the European Space Agency in 2004. After sleeping (and perchance, dreaming), for ten years, its alarm clock went off and it entered orbit around a comet while it was still inbound to the Sun. Two years later the mission's revels are nearly ended, and the data are being analyzed, wherein we hope to capture the conscience of the comet.





Our observatory is near the center of Lexington with a population of ~300,000. In addition to our teaching mission, what can be done with a 20" telescope in this environment?



Nova Delphini 2013
Approximate Location
HR Delphinus
Nova Delphini 1967
Delphinus
Sagitta
The "Coathanger"
Asterism

Cygnus

Lyra

M92

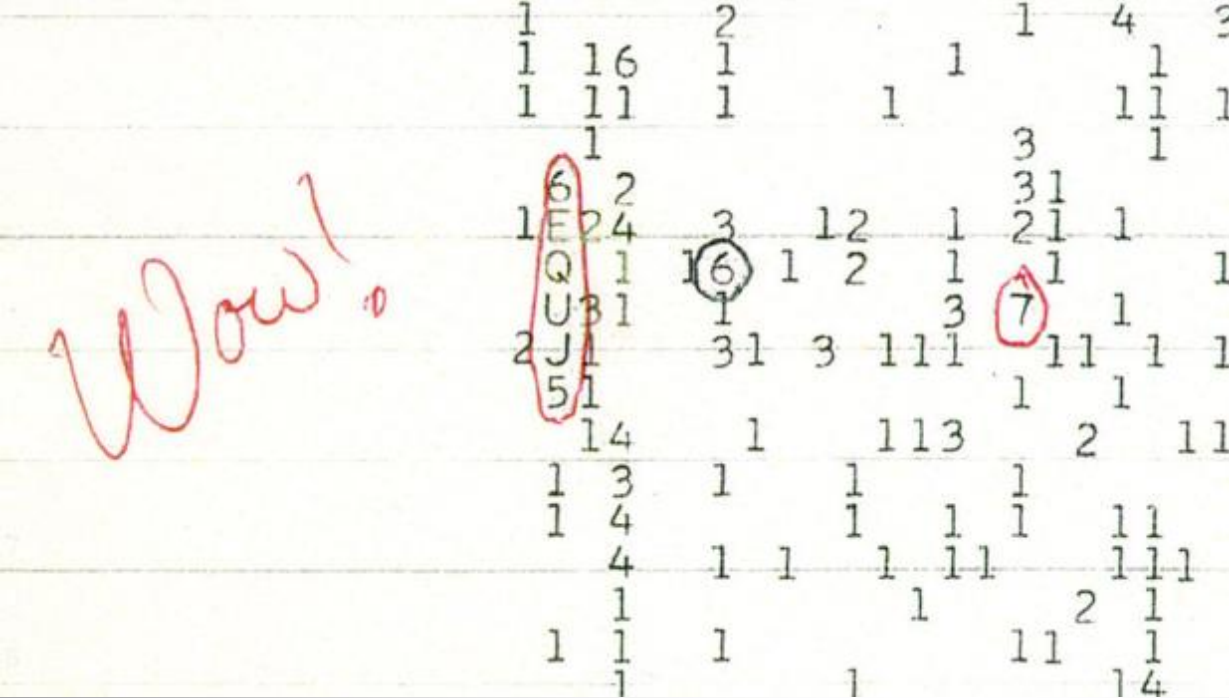
M13

Hercules

Aquila

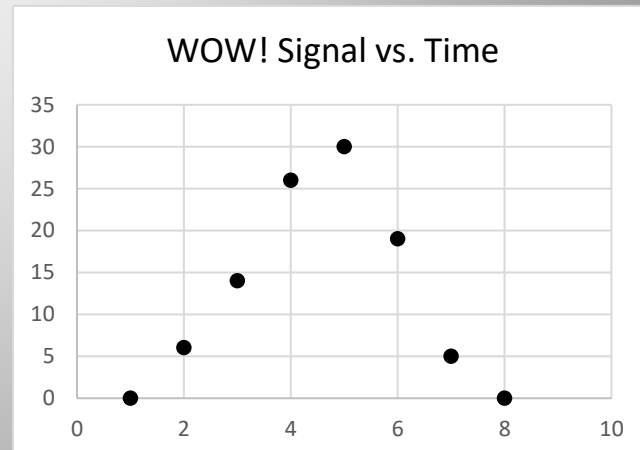
Where is That Star in the Sky? (And will it stay there?)

The stars seem fixed: static and unchanging. Neither is true if you take the long view. As the Galaxy rotates, our neighbors will drift away and new ones will take their places. Our observing platform, the Earth, rotates and wobbles on its axis, revolves around the Sun, and is in orbit around the Galactic center. Stars are often found in orbit around each other. Close observation of these motions can tell us a lot about the universe.



The "WOW!" Signal, 40 Years On

On August 15, 1977 a radio telescope in Ohio recorded a strong but brief and heretofore unexplained signal from space. Intermittent monitoring of the same part of the sky has revealed nothing. While many interpretations of the radio emission have been offered, none have been completely satisfactory: Earth-orbiting satellites, interstellar gas clouds, chance alignments of a comet, an alien civilization. In this SkyTalk, we will review the latest research and ask the question, "What would another galactic civilization hear if they were listening in on us?"





Powers of Ten



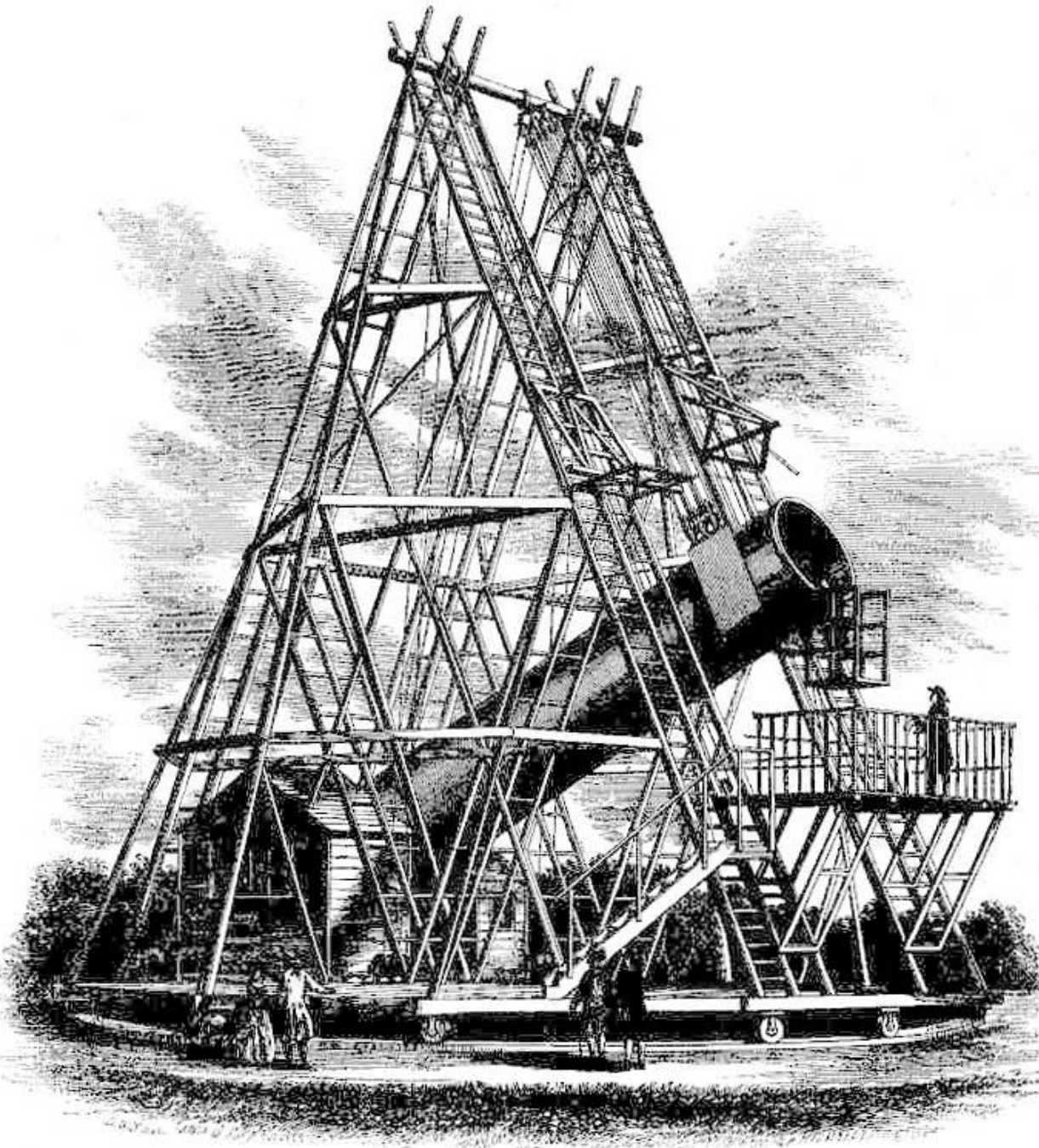
The scale of the known universe from the very small to the very large covers a scale of 45 orders of magnitude. That is, the largest structures are 1,000,000,000,000,000,000,000,000,000,000,000,000,000,000 times larger than the smallest. In this SkyTalk, we will start small and work our way out in *powers of ten*, each object being ten times larger than the previous one. In this way, we can examine the entire universe in 45 slides. We will finish with the short film, *Powers of Ten* by Raye & Charles Eames, narrated by Philip Morrison.

Keep Looking Up: The Heavenward Herschels

The Family Herschel, William, Caroline, and John, were the most productive astronomers of their times. They bridged the visual and photographic eras in astronomy, and catalogued thousands of faint, fuzzy objects in the night sky. To the Herschels we owe the words “infrared,” “asteroid,” and “photography.” William claimed:

“I have looked further into space than ever human being did before me. I have observed stars of which the light, it can be proved, must take two million years to reach the earth.”

And so he did. In this SkyTalk we will visit the highlights of this remarkable family and sample modern images of what they saw in the eyepiece 200 years ago.



Pleiades



Mars in Fact and Fiction

Mars is the only planet with a surface visible from Earth. It's a small world, about half the diameter of Earth, and therefore difficult to observe in detail. Real progress in understanding Mars had to wait for the space age.

Mars



Aldebaran



Mars Among the Stars of Taurus

(Tim Knauer 1990-09-15)



Clouds: Bane, Boon, and Boom

Clouds are found on all of the major planets except Mercury. They can have a profound influence on planetary weather. There are clouds of gas and dust in the Milky Way that form stars. Galaxies were once called "spiral nebulae." Clouds give astronomers something to look at -- when it's cloudy. Clouds are the most significant insubstantial things in the universe. Image: Tim Knauer

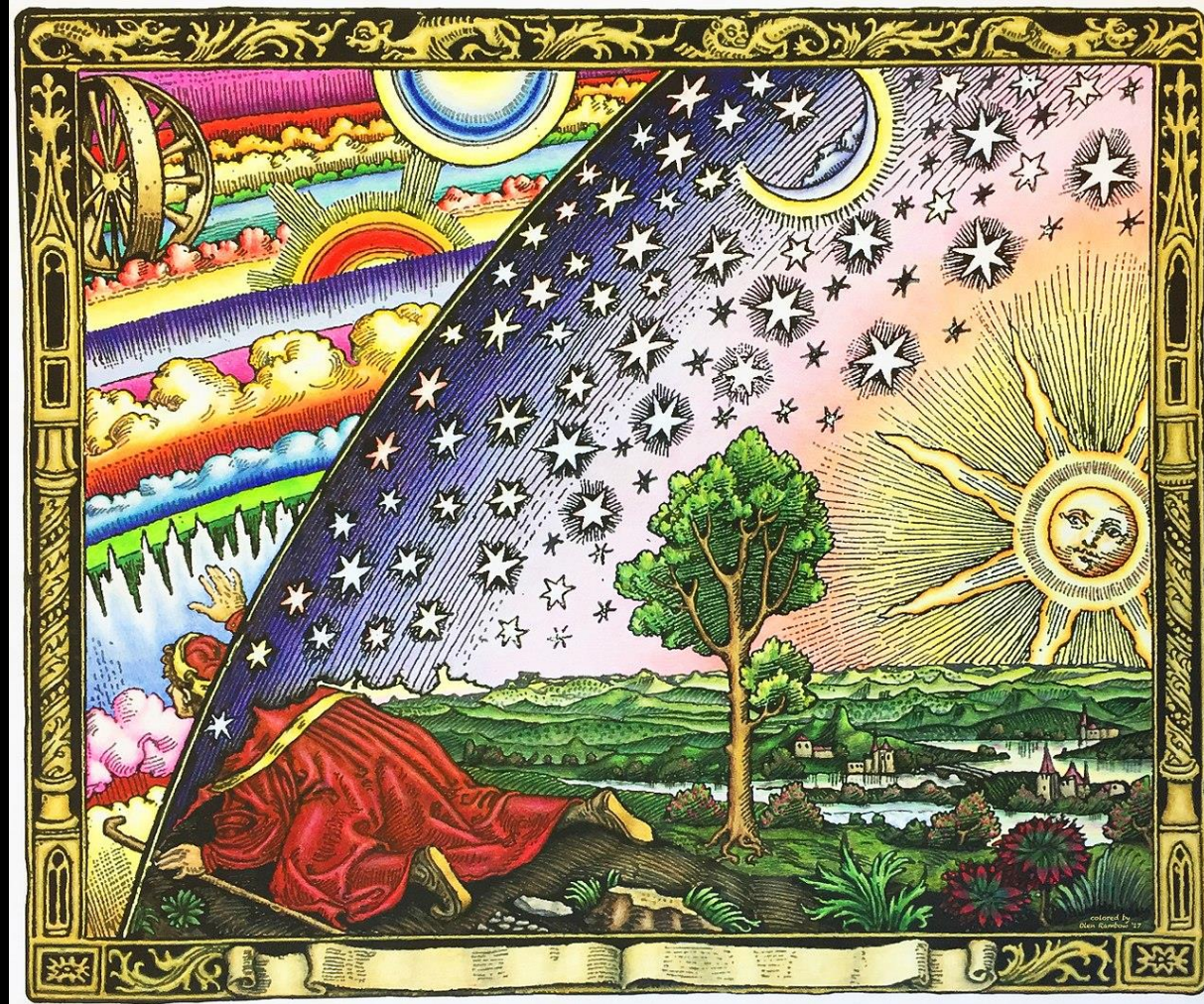


A Blast from the Past: Tambora at 200 Years

200 years ago, 70,000 people were killed, nearly instantly, on the island of Sumbawa in the Dutch East Indies. The eruption had global and lasting consequences. Fortunately, we live in Kentucky and have no risk of danger from volcanism. Or do we?

Image of Anak Krakatau : **Credit & Copyright:** [Marco Fulle](#)

Colorized version of a print from
Camille Flammarion's: *The Atmosphere*,
Popular Meteorology (1888)
Image: Houston Physicist

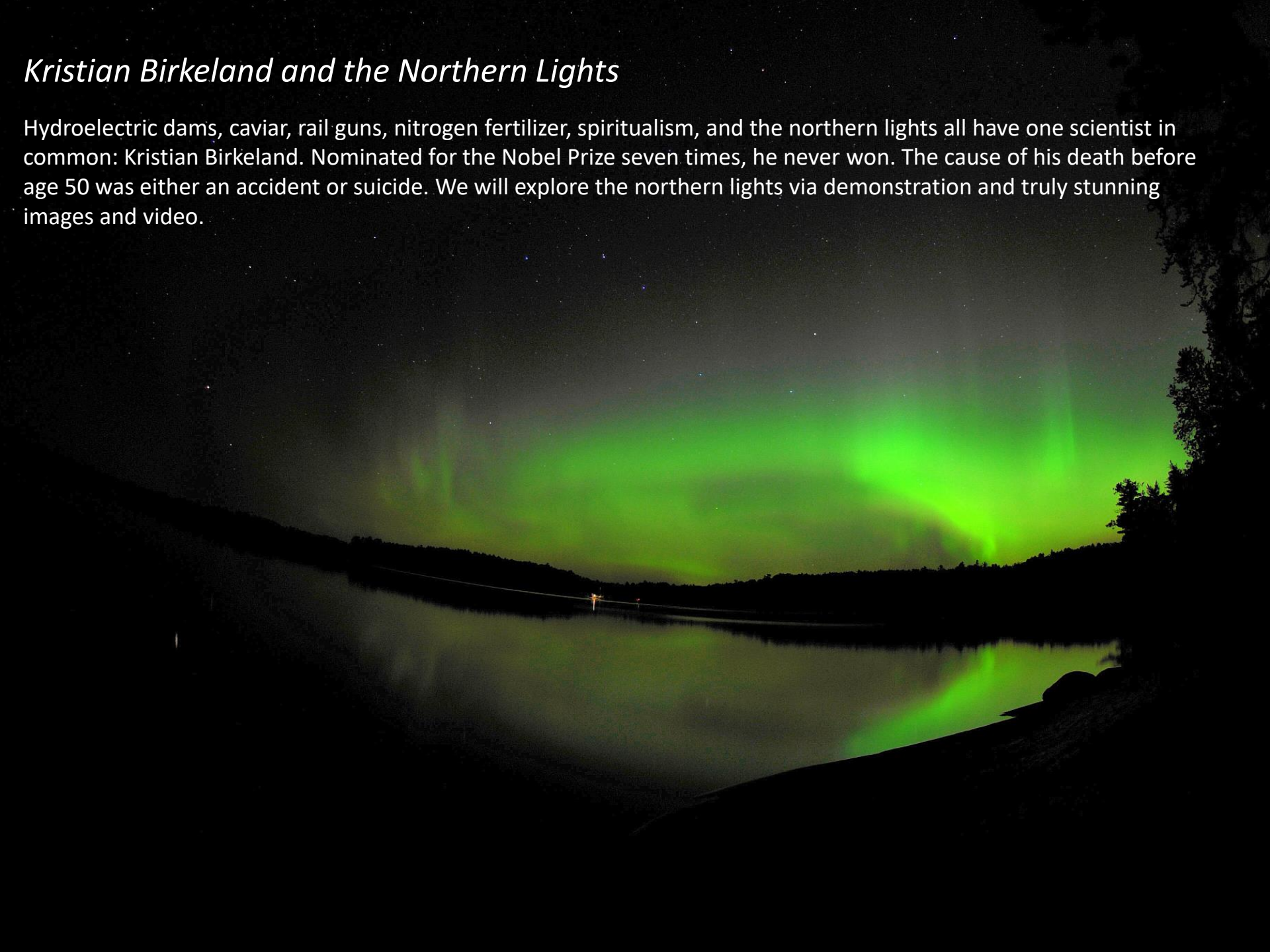


Wanted: A Planet With a View

The Earth is in a “Goldilocks” environment: not too far nor too close to the Sun. The Sun itself is in a bubble of space nearly devoid of obscuring galactic gas and dust. There are many places that would offer a completely different view of the universe. There are places where we would not choose to live, places where we could not survive.

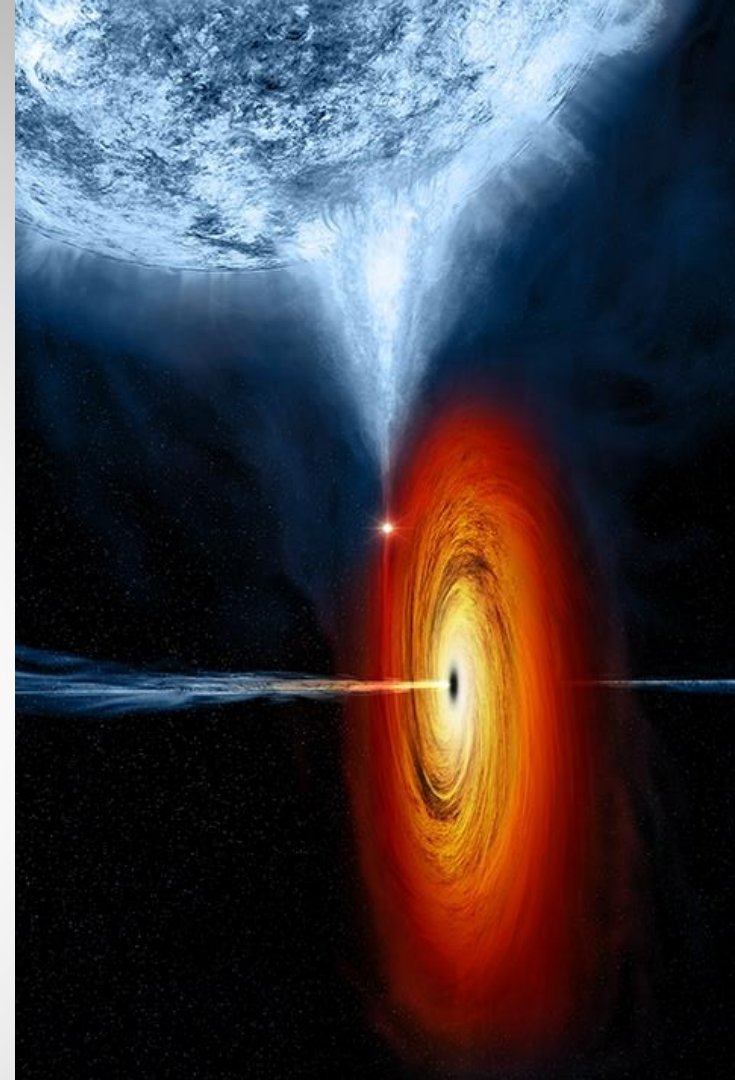
Kristian Birkeland and the Northern Lights

Hydroelectric dams, caviar, rail guns, nitrogen fertilizer, spiritualism, and the northern lights all have one scientist in common: Kristian Birkeland. Nominated for the Nobel Prize seven times, he never won. The cause of his death before age 50 was either an accident or suicide. We will explore the northern lights via demonstration and truly stunning images and video.





Original Apple Computer logo



<http://chandra.harvard.edu/photo/2011/cygx1/>

A History of Gravity: 300 Years of an Attractive Theory

Isaac Newton proposed Universal Gravitation in 1687, when at the insistence of Halley, the [*Principia Mathematica*](#) was published. In it was a remarkable assertion: that a force existed between the Sun and the Earth; the Earth and the Moon; the Earth and an apple. The notion that these forces were the same everywhere was, and remains, a novel idea. Newton's theory was sufficient until the middle of the 19th century when technology developed the precision to expose inconsistencies. In 1915 Einstein advanced a theory that extended Newton's ideas of gravity. Since then, the most exquisitely subtle experiments have been performed to test Newton and Einstein. To the current limits of precision, these theories have been confirmed. But are they complete?

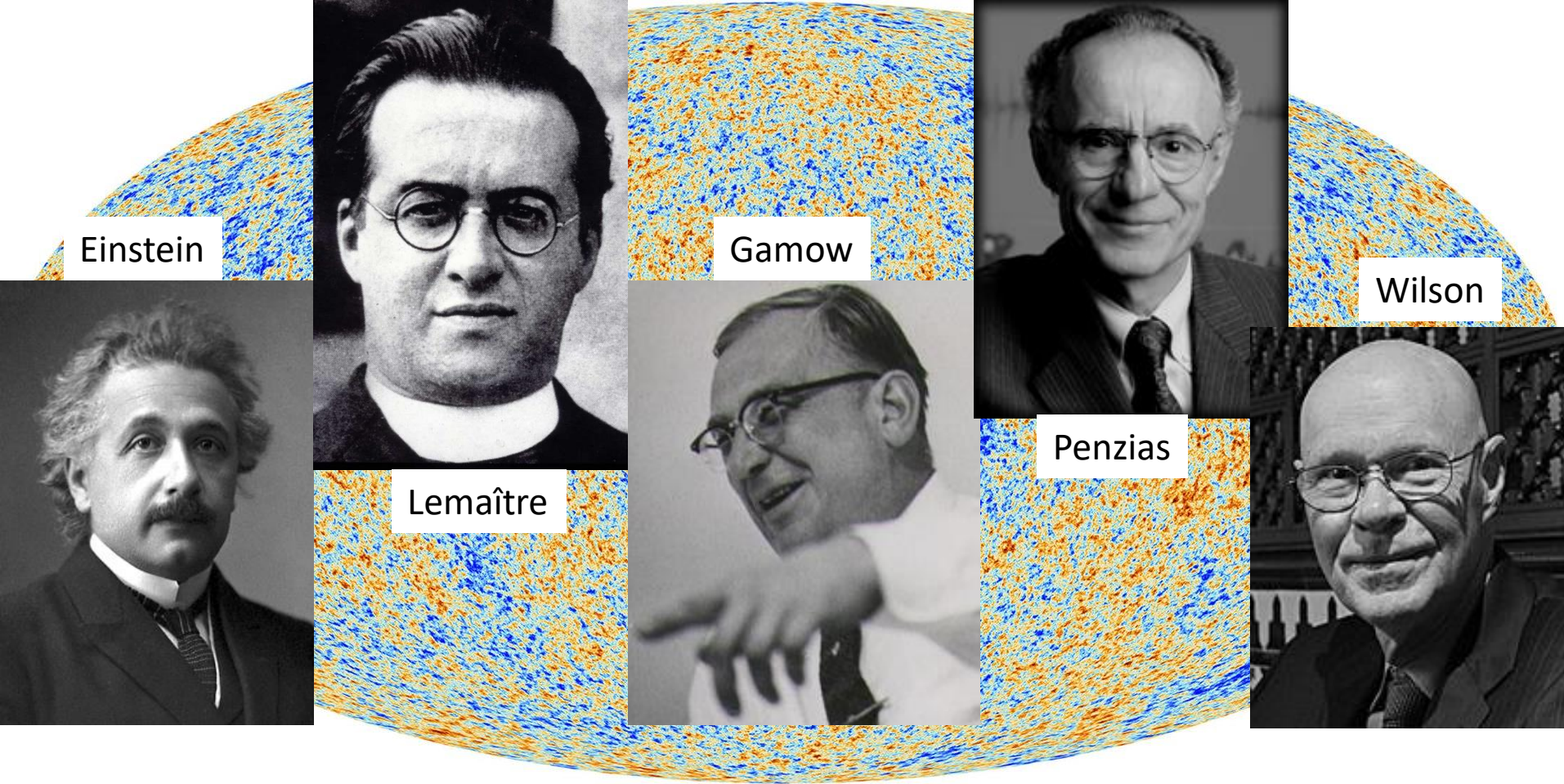
Barnard's "S" nebula

Yuri Beletsky(Las Campanas
Observatory,Carnegie Institution for Science)



Dark Clouds Don't Always Mean Stormy Weather

In fact, clouds of dust are essential to the formation of stars, planets, and people. Virtually everything you've ever seen or touched is made from recycled star dust. Yet, we've only been aware of stuff between the stars for about a century. The convincing visual evidence was provided by an elementary school drop-out, a portrait photographer's assistant. In this SkyTalk we will focus on galactic dust and the life of E. E. Barnard.



Einstein

Gamow

Wilson

Lemaître

Penzias

The Real Big Bang Theory

The story of the Big Bang goes back to the origins of written history. The modern version begins with a Belgian Abbé, detours through astronomy, physics, and finally switched through the telephone company. The idea has been debated, laughed at, awarded several Nobel Prizes, and lastly, taken root in our popular culture.

The notion of a universe that had a definite beginning is as perplexing as one that always was and always will be. Why should you believe that the universe has a shelf life?