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EINASTO, FREEMAN, TULLY, AND VAN DEN BERGH SHARE $500,000 GRUBER COSMOLOGY PRIZE FOR INVESTIGATIONS OF NEARBY UNIVERSE


Jaan Einasto


Kenneth Freeman


R. Brent Tully


Sidney van den Bergh

June 10, 2014, New Haven, CT – The 2014 Gruber Foundation Cosmology Prize recognizes Jaan Einasto, Kenneth Freeman, R. Brent Tully, and Sidney van den Bergh for their individual roles in the development of Near Field Cosmology.

"We want to recognize their pioneering contributions to the understanding of the structure and composition of the nearby universe," says Wendy Freedman, chair of the Selection Advisory Board to the Prize. "Their decades-long observations and analyses of relatively local galaxies have allowed cosmologists—including themselves—to investigate the evolution of the universe on the largest scales."

The Prize will be presented to Einasto, Freeman, Tully, and van den Bergh in a ceremony at Yale University on October 1, 2014.

Their award-winning work on the nearby universe quietly emerged during a period when cutting-edge cosmology was focused instead on the farthest reaches of the universe. As recently as the 1920s, astronomers were unsure whether anything existed beyond the realm of stars we call the Milky Way galaxy, but then came two key discoveries. The first, by Ernst Öpik (1922) and Edwin Hubble (1925), is that other galaxies do indeed exist – and today we know they number well over 100 billion. The second, by Hubble (1929), is that those galaxies are, on the whole, moving away from one another— according to general relativity, carried along by the expansion of space itself. Because light from an object takes time to reach us, astronomers realized they might be able to trace the evolution of the universe by looking into the distant past—by examining the infant universe and, epoch by epoch, working their way forward.

This year's Gruber recipients, however, stayed closer to home—and the present. Their work has allowed cosmologists to examine the mature universe and work their way backward.

Operating independently of one another, the four astronomers studied our Milky Way galaxy, the galaxies in the Local Group, and other nearby objects, devising strategies and making discoveries that have led to two fundamental changes in our interpretation of the universe:

- On the largest scales, the universe resembles a web of neurons—vast filaments of galaxies and superclusters of galaxies separated by even vaster voids.
- This structure would not be possible if the universe didn't have an invisible gravitational component—what we now call dark matter.

Sidney van den Bergh, who spent much of his career at the University of Toronto and the National Research Council of Canada's Dominion Astrophysical Observatory in Victoria, British Columbia, and is now retired, has been studying the present universe for clues to its past since the mid-1950s. He used variable stars—stars that brighten and dim in a regular pattern—to determine the distance to our neighboring Andromeda galaxy, thereby establishing one of the first rungs on the "cosmic distance ladder" that astronomers now use to measure the size of the universe.

Van den Bergh's work helped to overturn prevailing wisdom as to how galaxies form—that a single rotating cloud of gas flattens into a disk where star formation could begin. That hypothesis predicts that the stars in the outermost areas of the galaxy disk—the halo—would be the youngest in the galaxy. But in observing the halo of the Andromeda galaxy, van den Bergh discovered clusters of stars that are among the oldest, suggesting that they are remnants from galaxies that had merged with Andromeda. His radical conclusion is now the consensus: Galaxy mergers play a fundamental role in galaxy evolution.

R. Brent Tully, who has been an astronomer at the University of Hawaii since 1975, came to prominence with the publication of a 1977 paper, written with J. Richard Fisher, proposing a relationship between the mass of galaxies and their luminosities. Measure the mass of a galaxy, and you'll know the galaxy's intrinsic brightness; compare the intrinsic brightness with its observed brightness, and you'll know its distance (much as you could calculate the distance of a light bulb if you knew its wattage). The Tully-Fisher relation, which remains a standard tool in astronomy to this day, has allowed astronomers to determine distances to galaxies, the key measurement that endows the universe with a third dimension.

In 1988, Tully published The Nearby Galaxies Catalog, along with the Nearby Galaxies Atlas, the first major attempt to illustrate the 3D distribution of galaxies. Using 3D locations approximated from redshifts and a simple model, he mapped 2400 nearby galaxies. The atlas has never been duplicated on paper. At intervals, Tully has also published catalogs of directly measured distances. The most recent, in 2013, released distances for over 8,000 galaxies, which is the largest assembly of distance currently available.

Kenneth Freeman, who has worked at the Mount Stromlo Observatory of the Australian National University in Canberra nearly continuously since 1967, played a key role in understanding the effects of galactic halos in galaxies. He was one of the first astronomers to recognize the role and importance of dark matter in spiral galaxies.

In recent years Freeman, with his colleague Bland-Hawthorn, founded a field that has come to be known as "galactic archeology." They argue that stars in our galaxy with identical chemical compositions over

many chemical elements were born together in clusters and then, over the course of hundreds of millions or even billions of years, widely dispersed through the rotation of the galaxy. Astronomers can use these dispersed clusters to measure the star formation history of the galaxy. By observing where the stars are now, they can rewind the galaxy, so to speak, until the stars reach their common origin—movements that in turn trace the evolution of the galaxy itself.

Jaan Einasto, who has been at Tartu Observatory in Tõravere, Estonia, since his days as an undergraduate in the late 1940s, has made dark matter his specialty. In the 1960s his analysis of available data on our galaxy as well as all other galaxies in the Local Group led him to conclude that what we now call dark matter dominates the constitution of their haloes. In 1974 his research group at Tartu argued that all giant galaxies have massive dark coronae, forming a non-stellar population of an unknown nature (later it was understood that dark matter consists of hypothetical cold non-baryonic particles). Even so, their argument continued, the total amount of mass is only about twenty-five percent of the crucial density required to ultimately halt the expansion of the universe from gravitational attraction. Recent observations indicate that the major component of the mass-energy density adding to the so-called critical value is a dark energy that causes space to expand. Astronomers tend to think now that the expansion will continue – and continue to speed up – forever.

Einasto also was a pioneer in creating computer models, based on real data, that show the structure of the universe resembles a cosmic web—filaments of galaxies and galaxy superclusters separated by voids of empty space. Those computer models also show that such structures couldn't have evolved without the help of a significant dark matter component. Einasto first reported these findings at an international conference in Tallinn in 1977; he helped organized the event, itself a significant achievement for a scientist living in a Soviet satellite nation. At that conference, not only did East meet West, but the study of the small-scale nearby universe converged with the astronomy of, as the conference was called, "The Large-Scale Structure of the Universe."

The work begun by Einasto, Freeman, Tully, and van den Bergh is now called Near Field Cosmology, a seemingly paradoxical name that nonetheless encapsulates their collective vision: To study the universe on the largest scale, think small.

Additional Information

In addition to the cash award, each recipient will receive a gold laureate pin and a citation that reads:

The Gruber Foundation proudly presents the 2014 Cosmology Prize to Jaan Einasto, Kenneth Freeman, Brent Tully and Sidney van den Bergh for their pioneering contributions to the understanding of the structure and composition of the nearby Universe.

Their work laid the foundations of Near Field Cosmology. They clarified the properties of nearby galaxies -- dwarfs, spirals, lenticulars and ellipticals -- through studies of their morphology, stellar and gaseous content. The early recognition of the role of dark matter, and of the filamentary clustering of galaxies together with setting the distance scale of galaxies was crucial in setting the cosmological context for our current understanding of the evolution of galaxies and large-scale structure.

Laureates of the Gruber Cosmology Prize:

- **2013: Viatcheslav Mukhanov** and **Alexei Starobinsky** for their profound contribution to inflationary cosmology and the theory of inflationary perturbations of the metric. These developments changed our views on the origin of our universe and on the mechanism of formation of its structure.
- **2012: Charles Bennett and the WMAP Team** for their exquisite measurements of anisotropies in the relic radiation from the Big Bang---the Cosmic Microwave Background.
- **2011: Marc Davis, George Efstathiou, Carlos Frenk** and **Simon White** for their pioneering use of numerical simulations to model and interpret the large-scale distribution of matter in the Universe
- **2010: Charles Steidel** for his groundbreaking studies of the distant Universe
- **2009: Wendy Freedman, Robert Kennicutt** and **Jeremy Mould** for the definitive measurement of the rate of expansion of the universe, Hubble's Constant
- **2008: J. Richard Bond** for his pioneering contributions to our understanding of the development of structures in the universe
- **2007: Saul Perlmutter** and **Brian Schmidt** and their teams: the **Supernova Cosmology Project** and the **High-z Supernova Search Team,** for independently discovering that the expansion of the universe is accelerating
- **2006: John Mather** and the **Cosmic Background Explorer (COBE) Team** for studies confirming that our universe was born in a hot Big Bang
- **2005: James E. Gunn** for leading the design of a silicon-based camera for the Hubble Space Telescope and developing the original concept for the Sloan Digital Sky Survey
- **2004: Alan Guth** and **Andrei Linde** for their roles in developing and refining the theory of cosmic inflation
- **2003: Rashid Alievich Sunyaev** for his pioneering work on the nature of the cosmic microwave background and its interaction with intervening matter
- **2002: Vera Rubin** for discovering that much of the universe is unseen black matter, through her studies of the rotation of spiral galaxies
- **2001: Martin Rees** for his extraordinary intuition in unraveling the complexities of the universe
- **2000: Allan R. Sandage** and **Phillip J. E. (Jim) Peebles**: Sandage for pursuing the true values of the Hubble constant, the deceleration parameter and the age of the universe; Peebles for advancing our understanding of how energy and matter formed the rich patterns of galaxies observed today

The Prize recipients are chosen by the Cosmology Selection Advisory Board. Its members are:

Andrew Fabian, University of Cambridge; **Wendy Freedman,** The Observatories of the Carnegie Institution of Washington (Chair); **Gerhard Huisken,** Max Planck Institute for Gravitational Physics; **Helge Kraghe,** Aarhus University; **Sadanori Okamura,** Hosei University; **Subir Sarkar**, University of Oxford; and **Rashid Sunyaev**, Max Planck Institute for Astrophysics. **Owen Gingerich** of the Harvard-Smithsonian Center for Astrophysics and **Martin Rees** of the University of Cambridge also serve as special Cosmology advisors to the Foundation.

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By agreement made in the spring of 2011 The Gruber Foundation has now been established at Yale University.

The Gruber International Prize Program honors individuals in the fields of Cosmology, Genetics and Neuroscience, whose groundbreaking work provides new models that inspire and enable fundamental shifts in knowledge and culture. The Selection Advisory Boards choose individuals whose contributions in their respective fields advance our knowledge and potentially have a profound impact on our lives.

The Cosmology Prize honors a leading cosmologist, astronomer, astrophysicist or scientific philosopher for theoretical, analytical, conceptual or observational discoveries leading to fundamental advances in our understanding of the universe.

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Affiliation with International Astronomical Union

In 2000, The Foundation and the International Astronomical Union (IAU) announced an agreement by which the IAU provides its expertise and contacts with professional astronomers worldwide for the nomination and selection of Cosmology Prize recipients. Under the agreement, The Gruber Foundation also funds a fellowship program for young astronomers, with the aim of promoting the continued recruitment of new talent into the field.

The International Astronomical Union, founded in 1919, is an organization of professional astronomers. It serves today a membership of more than 9,000 individual astronomers from 85 countries, worldwide. Information about the activities of the IAU is available from www.iau.org .

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For more information on the Gruber Prizes, visit www.gruber.yale.edu , e-mail info@gruber.yale.edu or contact A. Sarah Hreha at +1 (203) 432-6231. By mail: The Gruber Foundation, Yale University, Office of Development, PO Box 2038, New Haven, CT 06521.

Media materials and additional background information on the Gruber Prizes can be found at our online newsroom: http://gruber.yale.edu/news-media