Our Heritage

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Astrophysics and Deep Space

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ABSTRACT: -Astrophysics is the part of astronomy that utilizes the standards of material science and science "to learn the idea of the galactic items, instead of their positions or movements in space".Among the articles contemplated are the Sun, different stars, universes, extra solar planets, the interstellar medium and the inestimable microwave background. Emissions from these articles are inspected over all pieces of the electromagnetic range, and the properties analyzed incorporate iridescence, thickness, temperature, and concoction structure. Since astrophysics is an exceptionally expansive subject, astrophysicists apply ideas and techniques from numerous orders of material science, including old style mechanics, electromagnetism, measurable mechanics, thermodynamics, quantum mechanics, relativity, atomic and molecule physical science, and nuclear and sub-atomic physical science.

Practically speaking, current galactic research regularly includes a significant measure of work in the domains of hypothetical and observational material science. A few regions of study for astrophysicists incorporate their endeavours to decide the properties of dull issue, dim vitality, dark gaps, and other heavenly bodies; regardless of whether time travel is potential, wormholes can shape, or the multiverse exists; and the cause and extreme destiny of the universe.[3] Topics likewise concentrated by hypothetical astrophysicists incorporate Solar System arrangement and advancement; outstanding elements and development; world arrangement and development; magneto hydrodynamics; huge scope structure of issue in the universe; starting point of enormous beams; general relativity, unique relativity, quantum and physical cosmology, including string cosmology and astroparticle material science.

INTRODUCTION: - Astrophysics is the study of physical procedures in the universe. It utilizes information assembled by stargazers utilizing telescopes on Earth and in space – joined with the laws and hypotheses of material science – so as to decipher the universe around us. In the event that astronomy asks what and where, astrophysics asks how and for what good reason. A sister science – planetary science – contemplates the planets in our close planetary system and inaccessible universes in our Milky Way cosmic system. Another sister science – cosmology – considers outside worlds and voids, and the enormous scope structure and history of the universe.

For instance, a space expert may go through evenings at the telescope gathering information on a star. Putting on their astrophysicist cap – and relying upon which instruments were

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utilized related to the telescope (photometers or spectrometers, for instance) – that researcher would then go to the laws of material science to see how that star creates its vitality, regardless of whether it has a buddy (or maybe planets, or maybe a circling plate), and how the star travels through space. Galactic astrophysicists would then ask how that star fits with what's thought about our Milky Way system. Cosmologists would then solicit how the information from the stars fits with that of the universe all in all.

Also, by the route these names – space expert, astrophysicist, cosmologist, for instance – might portray a solitary individual whose activity is to examine and comprehend the universe.

Additionally this portrayal is only an incredibly, oversimplified perspective on what space experts/astrophysicists/cosmologists really do. They may, for instance, bring numerous different sciences into their investigations: science, topography, science and the sky is the limit from there. They'll bring the entirety of this information into centre utilizing an incredible and complex arms stockpile of speculations, instruments and computational force that would have been unbelievable only a couple of decades prior. The entirety of the devices of astronomy, all its different gadgets, information, speculations and pathways of study, are looking to respond to mankind's greatest inquiries. How did our universe arrive? What's its history? Where did we originate from? Are there others like us, somewhere else in the universe?

History of Astrophysics

The historical backdrop of astrophysics truly starts in Europe with the Renaissance, when astronomy lost the shackles of ages old legends and turned into a genuine science. In Florence, in 1610, Galileo Galilei got one of the first to turn the telescope to the sky, uncovering a universe inconsistent with the prohibitive lessons of the Church. By 1633, this risky logical inconsistency saw Galileo attempted by the Roman Inquisition and limited to house capture for an amazing remainder until his demise in 1642.

In England in 1665, Isaac Newton, having fled Cambridge University to get away from the Great Plague, settled back in the town of his introduction to the world, the rustic network of Woolsthorpe, Lincolnshire. Throughout the following quite a long while, he created math and progressive thoughts regarding light. In 1687, he distributed his Law of Universal Gravitation, expressing that each molecule pulls in each other molecule in the universe with a power that is legitimately corresponding to the result of their masses and conversely relative to the square of the separation between them. Just because, researchers could compute the power of fascination between objects in space. This was a mammoth advance forward in researchers' capacity to comprehend the sky.

Astronomy is an antiquated science, since quite a while ago isolated from the investigation of earthbound material science. In the Aristotelian perspective, bodies in the sky seemed, by all accounts, to be constant circles whose solitary movement was uniform movement around,

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while the natural world was the domain which experienced development and rot and in which regular movement was in a straight line and finished when the moving article arrived at its goal. Subsequently, it was held that the divine district was made of an on a very basic level diverse sort of issue from that found in the earthbound circle; either Fire as kept up by Plato, or Aether as kept up by Aristotle. During the seventeenth century, common scholars, for example, Galileo, Descartes, and Newton started to keep up that the heavenly and earthly areas were made of comparable sorts of material and were dependent upon a similar regular laws. Their test was that the instruments had not yet been created with which to demonstrate these assertions.

For a significant part of the nineteenth century, galactic research was centered around the standard work of estimating the positions and processing the movements of cosmic objects. Astronomy, destined to be called astrophysics, started to develop when William Hyde Wollaston and Joseph von Fraunhofer autonomously found that, while breaking down the light from the Sun, a large number of dull lines (locales where there was less or no light) were seen in the spectrum. By 1860 the physicist, Gustav Kirchhoff, and the scientist, Robert Bunsen, had shown that the dim lines in the sun powered range compared to splendid lines in the spectra of known gases, explicit lines relating to one of a kind substance elements. Kirchhoff reasoned that the dim lines in the sun based range are brought about by retention by compound components in the solar atmosphere. Thusly it was demonstrated that the synthetic components found in the Sun and stars were likewise found on Earth.

Among the individuals who expanded the investigation of sun based and outstanding spectra was Norman Lockyer, who in 1868 distinguished brilliant, just as dull, lines in sun oriented spectra. Working with the scientist, Edward Frankland, to examine the spectra of components at different temperatures and weights, he was unable to relate a yellow line in the sunlight based range with any known components. He in this manner asserted the line spoke to another component, which was called helium, after the Greek Helios, the Sun personified.

In 1885, Edward C. Pickering embraced an eager program of excellent otherworldly grouping at Harvard College Observatory, in which a group of lady PCs, strikingly Williamina Fleming, Antonia Maury, and Annie Jump Cannon, ordered the spectra recorded on photographic plates. By 1890, an inventory of more than 10,000 stars had been readied that assembled them into thirteen ghostly sorts. Following Pickering's vision, by 1924 Cannon extended the inventory to nine volumes and over a fourth of a million stars, building up the Harvard Classification Scheme which was acknowledged for overall use in 1922.

In 1895, George Ellery Hale and James E. Keeler, alongside a gathering of ten partner editors from Europe and the United States, set up The Astrophysical Journal: An International Review of Spectroscopy and Astronomical Physics. It was expected that the diary would fill the hole between diaries in astronomy and material science, giving a setting to production of articles on galactic utilizations of the spectroscope; on lab inquire about firmly associated to cosmic physical science, including frequency judgments of metallic and vaporous spectra and

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investigations on radiation and retention; on hypotheses of the Sun, Moon, planets, comets, meteors, and nebulae; and on instrumentation for telescopes and laboratories.

Around 1920, after the disclosure of the Hertzsprung–Russell outline despite everything utilized as the reason for arranging stars and their development, Arthur Eddington foreseen the revelation and component of atomic combination forms in stars, in his paper The Internal Constitution of the Stars. Around then, the wellspring of outstanding vitality was a finished puzzle; Eddington effectively hypothesized that the source was combination of hydrogen into helium, freeing colossal vitality as per Einstein's condition E = mc2. This was an especially striking improvement since around then combination and nuclear vitality, and even that stars are to a great extent made out of hydrogen (see metallicity), had not yet been discovered.[non-essential source needed]

In 1925 Cecilia Helena Payne (later Cecilia Payne-Gaposchkin) composed a persuasive doctoral thesis at Radcliffe College, in which she applied ionization hypothesis to excellent environments to relate the phantom classes to the temperature of stars. Most fundamentally, she found that hydrogen and helium were the chief segments of stars. In spite of Eddington's recommendation, this revelation was unforeseen to the point that her paper perusers persuaded her to adjust the end before distribution. In any case, later research affirmed her discovery.

Before the finish of the twentieth century, investigations of galactic spectra had extended to cover frequencies reaching out from radio waves through optical, x-beam, and gamma wavelengths. In the 21st century it further extended to incorporate perceptions dependent on gravitational waves.

Observational Astrophysics

Observational astronomy is a division of the galactic science that is worried about chronicle and deciphering information, conversely with hypothetical astrophysics, which is chiefly worried about discovering the quantifiable ramifications of physical models. It is the act of watching heavenly items by utilizing telescopes and other cosmic contraption.

Most of astrophysical perceptions are made utilizing the electromagnetic range.

- Radio astronomy considers radiation with a frequency more prominent than a couple of millimetres. Model zones of study are radio waves, as a rule discharged by chilly articles, for example, interstellar gas and residue mists; the infinite microwave foundation radiation which is the redshirted light from the Big Bang; pulsars, which were first recognized at microwave frequencies. The investigation of these waves requires huge radio telescopes.
- Infrared astronomy considers radiation with a frequency that is too long to ever be noticeable to the unaided eye yet is shorter than radio waves. Infrared perceptions are

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normally made with telescopes like the natural optical telescopes. Items colder than stars, (for example, planets) are regularly learned at infrared frequencies.

- Optical astronomy was the most punctual sort of astronomy. Telescopes matched with a charge-coupled gadget or spectroscopes are the most widely recognized instruments utilized. The Earth's climate meddles to some degree with optical perceptions, so versatile optics and space telescopes are utilized to get the most noteworthy conceivable picture quality. Right now, stars are profoundly obvious, and numerous concoction spectra can be seen to contemplate the synthetic creation of stars, cosmic systems and nebulae.
- Bright, X-beam and gamma beam astronomy concentrate exceptionally vivacious procedures, for example, double pulsars, dark gaps, magnetars, and numerous others. These sorts of radiation don't infiltrate the Earth's climate well. There are two techniques being used to watch this piece of the electromagnetic range—space-based telescopes and ground-based imaging air Cherenkov telescopes (IACT). Instances of Observatories of the primary kind are RXTE, the Chandra X-beam Observatory and the Compton Gamma Ray Observatory. Instances of IACTs are the High Energy Stereoscopic System (H.E.S.S.) and the MAGIC telescope.

Other than electromagnetic radiation, not many things might be seen from the Earth that begins from significant stretches. A couple of gravitational wave observatories have been developed, however gravitational waves are amazingly hard to distinguish. Neutrino observatories have additionally been constructed, principally to examine our Sun. Astronomical beams comprising of high vitality particles can be watched hitting the Earth's environment.

Perceptions can likewise shift in their time scale. Most optical perceptions take minutes to hours, so wonders that change quicker than this can't promptly be watched. In any case, chronicled information on certain articles is accessible, spreading over hundreds of years or centuries. Then again, radio perceptions may take a gander at occasions on a millisecond timescale (millisecond pulsars) or consolidate long stretches of information (pulsar deceleration contemplates). The data got from these distinctive timescales is totally different.

The investigation of our own special Sun has an uncommon spot in observational astrophysics. Because of the colossal separation of every single other star, the Sun can be seen in a sort of detail unmatched by some other star. Our comprehension of our own Sun fills in as a manual for our comprehension of different stars.

The subject of how stars change, or outstanding advancement, is frequently demonstrated by putting the assortments of star types in their particular situations on the Hertzsprung–Russell outline, which can be seen as speaking to the condition of an excellent article, from birth to decimation.

Theoretical Astrophysics

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Hypothetical astrophysicists utilize a wide assortment of apparatuses which incorporate explanatory models (for instance, polytropes to surmised the practices of a star) and computational numerical re-enactments. Every ha a few points of interest. Logical models of a procedure are commonly better for giving understanding into the core of what is happening. Numerical models can uncover the presence of marvels and impacts that would somehow or another not be seen.

Scholars in astrophysics attempt to make hypothetical models and make sense of the observational results of those models. This permits onlookers to search for information that can disprove a model or help in picking between a few interchange or clashing models.

Scholars likewise attempt to produce or adjust models to consider new information. On account of an irregularity, the general inclination is to attempt to make insignificant adjustments to the model to fit the information. Sometimes, a lot of conflicting information after some time may prompt absolute deserting of a model.

Points concentrated by hypothetical astrophysicists incorporate excellent elements and development; world arrangement and advancement; magneto hydrodynamics; enormous scope structure of issue in the universe; starting point of grandiose beams; general relativity and physical cosmology, including string cosmology and astroparticle material science. Astrophysical relativity fills in as an instrument to check the properties of huge scope structures for which attraction assumes a noteworthy job in physical wonders examined and as the reason for dark opening (astro) physics and the investigation of gravitational waves.

Some broadly acknowledged and contemplated hypotheses and models in astrophysics, presently remembered for the Lambda-CDM model, are the Big Bang, infinite swelling, dull issue, dim vitality and essential speculations of material science. Wormholes are instances of speculations which are yet to be demonstrated (or disproven).

DEEP SPACE EXPLORATION

Deep space investigation (or deep-space investigation) is the part of astronomy, astronautics and space innovation that is engaged with investigating the inaccessible areas of external space. However, there is little agreement on the significance of "far off" locales. In certain specific circumstances, it is utilized to allude to interstellar space. The International Telecommunication Union characterizes "deep space" to begin a ways off of 2 million km from the Earth's surface. NASA's Deep Space Network has differently utilized criteria of 16,000 to 32,000 km from Earth. Physical investigation of space is directed both by human spaceflights (deep-space astronautics) and by automated spacecraft.

At present the most distant space test humanity has developed and propelled from Earth is Voyager 1, which was declared on December 5, 2011, to have arrived at the external edge of the Solar system, and entered interstellar space on August 25, 2012. Deep space investigation

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farther than this current vessel's ability isn't yet conceivable because of restrictions in the space-motor innovation right now accessible.

Probably the best contender for future deep space motor innovations incorporate enemy of issue, atomic force and shot propulsion. The last mentioned, channelled impetus, has all the earmarks of being the best possibility for deep space investigation by and by accessible, since it utilizes known material science and known innovation that is being created for other purposes.

Current Research in Deep Space

In 2012, the Defence Advanced Research Projects Agency declared the honor of $500,000 to previous space explorer Mae Jemison to subsidize a task with the objective of sending future space travellers out of the Solar System. Jemison means to build open enthusiasm for future deep space investigation ventures. After granting the cash to Jemison, a "100 Year Starship" symposium was held in Houston, Texas, to talk about interstellar travel. Subjects examined incorporate "time-separation arrangements, life sciences in space investigation, goals and natural surroundings, turning into an interstellar human advancement, space innovations upgrading life on earth, and business openings from interstellar efforts".

Research in deep space is continuous and quickly creating. In 2011, after the retirement of the Space Shuttle, NASA reported its aims to put cash into creating three advances fundamental to deep space investigation. The "must-have advances" incorporate a deep space nuclear clock, an enormous sun oriented sail and a further developed laser correspondences framework to improve correspondence, route, and impetus in future missions.[9] In June 2013, NASA reported the determination of eight American space explorers that will start to prepare for future deep space missions past low Earth circle. NASA means that these eight space explorers to prepare for future Mars or space rock travel.

The Single Aperture Far-Infrared Observatory (SAFIR), a proposed cryogenic space telescope, is likely set to dispatch in 2015 with the expectations of investigating "the arrangement of the primary stars and cosmic systems" in deep space. The telescope will be in excess of multiple times more delicate than two current telescope spacecrafts, the Spitzer Space Telescope and the Herschel Space Observatory. NASA plans to utilize SAFIR to find out about dark openings, universe arrangement and advancement and the development of star frameworks in the furthest reaches of space.

CONCLUSION: -The underlying foundations of astrophysics can be found in the seventeenth century rise of a brought together material science, in which similar laws applied to the divine and earthbound realms. There were researchers who were qualified in the two physical science and astronomy who established the firm framework for the ebb and flow study of astrophysics. In present day times, understudies keep on being attracted to astrophysics because of its advancement by the Royal Astronomical Society and remarkable teachers, for

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example, unmistakable educators Lawrence Krauss, Subrahmanyan Chandrasekhar, Stephen Hawking, Hubert Reeves, Carl Sagan, Neil deGrasse Tyson and Patrick Moore. The endeavors of the early, late, and present researchers keep on pulling in youngsters to contemplate the history and study of astrophysics.

For quite a long time by the act of astronomy—first with the independent human eye, at that point compass and sextant, at long last with perpetually ground-breaking optical telescopes—mankind has embraced to outline twilight skies, with expectations of better managing route, developing precise schedules, and understanding normal cycles. Archaeological revelations recommend that astronomy might be the most established science, and Stonehenge one of the most huge, if not among the soonest, open air observatories. Utilizing a tremendous armamentarium of new imaging apparatuses, the cutting edge study of astrophysics starts with adaptive perspectives on the unmistakable sky. Yet, astrophysicists are then ready to utilize those perceptions to investigate the material science of gravity, to watch the activities of principal particles, and to contemplate other progressively outlandish marvels in space. From such investigations they create hypotheses about the inception, development, structure, and fate of the universe—the investigation of cosmology.

REFERENCES:-

1. Keeler, James E. (November 1897), "The Importance of Astrophysical Research and the Relation of Astrophysics to the Other Physical Sciences", The Astrophysical Journal, 6 (4): 271–288, Bibcode:1897ApJ.....6..271K, doi:10.1086/140401, [Astrophysics] is firmly associated from one perspective to astronomy, of which it might appropriately be classed as a branch, and then again to science and material science.… It tries to find out the idea of the wonderful bodies, as opposed to their positions or movements in space–what they are, instead of where they are.… That which is maybe generally normal for astrophysics is the extraordinary noticeable quality which it provides for the investigation of radiation.
2. "astrophysics". Merriam-Webster, Incorporated. Documented from the first on 10 June 2011. Recovered 2011-05-22.
3. "Center Areas – NASA Science". nasa.gov.
4. "astronomy". Encyclopædia Britannica.
5. Lloyd, G. E. R. (1968). Aristotle: The Growth and Structure of His Thought. Cambridge: Cambridge University Press. pp. 134–135. ISBN 978-0-521-09456-6.
6. Cornford, Francis MacDonald (c. 1957) [1937]. Plato's Cosmology: The Timaeus of Plato deciphered, with a running critique. Indianapolis: Bobbs Merrill Co. p. 118.
7. Galilei, Galileo (1989-04-15), Van Helden, Albert (ed.), SidereusNuncius or The Sidereal Messenger, Chicago: University of Chicago Press (distributed 1989), pp. 21, 47, ISBN 978-0-226-27903-9
8. Edward Slowik (2013) [2005]. "Descartes' Physics". Stanford Encyclopedia of Philosophy. Recovered 2015-07-18.

ISSN: 0474-9030

Vol-68-Issue-1-January-2020

9. Westfall, Richard S. (1983-04-29), Never at Rest: A Biography of Isaac Newton, Cambridge: Cambridge University Press (distributed 1980), pp. 731–732, ISBN 978-0-521-27435-7
10. Burtt, Edwin Arthur (2003) [First distributed 1924], The Metaphysical Foundations of Modern Science (second reconsidered ed.), Mineola, NY: Dover Publications, pp. 30, 41, 241–2, ISBN 978-0-486-42551-1
11. LadislavKvasz (2013). "Galileo, Descartes, and Newton – Founders of the Language of Physics" (PDF). Foundation of Philosophy, Academy of Sciences of the Czech Republic. Recovered 2015-07-18.
12. Case, Stephen (2015), "'Land-signs of the universe': John Herschel against the foundation of positional astronomy", Annals of Science, 72 (4): 417–434, Bibcode:2015AnSci..72..417C, doi:10.1080/00033790.2015.1034588, PMID 26221834, The incredible lion's share of stargazers working in the mid nineteenth century were not intrigued by stars as physical articles. A long way from being bodies with physical properties to be explored, the stars were viewed as markers estimated so as to build an exact, itemized and exact foundation against which sun powered, lunar and planetary movements could be graphed, fundamentally for earthbound applications.
13. Donnelly, Kevin (September 2014), "On the weariness of science: positional astronomy in the nineteenth century", The British Journal for the History of Science, 47 (3): 479–503, doi:10.1017/S0007087413000915
14. Hearnshaw, J.B. (1986). The investigation of starlight. Cambridge: Cambridge University Press. pp. 23–29. ISBN 978-0-521-39916-6.
15. Kirchhoff, Gustav (1860), "Ueber kick the bucket Fraunhofer'schenLinien", Annalen der Physik, 185 (1): 148–150, Bibcode:1860AnP...185..148K, doi:10.1002/andp.18601850115
16. Kirchhoff, Gustav (1860), "Ueber das VerhältnisszwischendemEmissionsvermögen und demAbsorptionsvermögen der KörperfürWärme und Licht", Annalen der Physik, 185 (2): 275–301, Bibcode:1860AnP...185..275K, doi:10.1002/andp.18601850205
17. Cortie, A. L. (1921), "Sir Norman Lockyer, 1836 – 1920", The Astrophysical Journal, 53: 233–248, Bibcode:1921ApJ....53..233C, doi:10.1086/142602
18. Jensen, William B. (2004), "Why Helium Ends in "- ium"" (PDF), Journal of Chemical Education, 81 (7): 944–945, Bibcode:2004JChEd..81..944J, doi:10.1021/ed081p944
19. Hetherington, Norriss S.; McCray, W. Patrick, Weart, Spencer R. (ed.), Spectroscopy and the Birth of Astrophysics, American Institute of Physics, Center for the History of Physics, filed from the first on September 7, 2015, recovered July 19, 2015
20. Sound, George Ellery (1895), "The Astrophysical Journal", The Astrophysical Journal, (1): 80–84, Bibcode:1895ApJ.....1...80H, doi:10.1086/140011
21. The Astrophysical Journal. (1).

ISSN: 0474-9030

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22. Eddington, A. S. (October 1920), "The Internal Constitution of the Stars", The Scientific Monthly, 11 (4): 297–303, JSTOR 6491, PMID 17747682
23. Eddington, A. S. (1916). "On the radiative balance of the stars". Month to month Notices of the Royal Astronomical Society. 77: 16–35. Bibcode:1916MNRAS..77...16E. doi:10.1093/mnras/77.1.16.
24. Payne, C. H. (1925), Stellar Atmospheres; A Contribution to the Observational Study of High Temperature in the Reversing Layers of Stars (PhD Thesis), Cambridge, Massachusetts: Radcliffe College, Bibcode:1925PhDT.....1P
25. Haramundanis, Katherine (2007), "Payne-Gaposchkin [Payne], Cecilia Helena", in Hockey, Thomas; Trimble, Virginia; Williams, Thomas R. (eds.), Biographical Encyclopedia of Astronomers, New York: Springer, pp. 876–878, ISBN 978-0-387-30400-7, recovered July 19, 2015
26. Biermann, Peter L.; Falcke, Heino (1998), "Wildernesses of Astrophysics: Workshop Summary", in Panvini, Robert S.; Weiler, Thomas J. (eds.), Fundamental particles and communications: Frontiers in contemporary material science a universal talk and workshop arrangement. AIP Conference Proceedings, 423, American Institute of Physics, pp. 236–248, arXiv:astro-ph/9711066, Bibcode:1998AIPC..423..236B, doi:10.1063/1.55085, ISBN 1-56396-725-1
27. Roth, H. (1932), "A Slowly Contracting or Expanding Fluid Sphere and its Stability", Physical Review, 39 (3): 525–529, Bibcode:1932PhRv...39..525R, doi:10.1103/PhysRev.39.525
28. Eddington, A.S. (1988) [1926], Internal Constitution of the Stars, New York: Cambridge University Press, ISBN 978-0-521-33708-3, PMID 17747682
29. D. Imprint Manley (2012). "Popular Astronomers and Astrophysicists". Kent State University. Recovered 2015-07-17.
30. The science.ca group (2015). "Hubert Reeves – Astronomy, Astrophysics and Space Science". GCS Research Society. Recovered 2015-07-17.
31. "Neil deGrasse Tyson". Hayden Planetarium. 2015. Recovered 2015-07-17.