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Figure 1. Whole body average reference levels for the general public for the ICNIRP (1998), ICNIRP (2010) and ICNIRP (2020) guidelines, for the 100 kHz to 300 GHz frequency range. Note that the units of the two y-axes (i.e. electric field a power density) are independent of each other.



517 (2): 565-86. This is why we will never know everything about our universe - Forbes, May 2019. ^ Although listed in megaparsecs by the cited source, this number is so vast that its digits would remain virtually unchanged for all intents and purposes regardless of which conventional units it is listed in, whether it to be nanometres or gigaparsecs, as the differences would disappear into the error. 527) ^ Bartel (1987, pp. In the degenerate cases, when n equals 0 or  $\pi/2$ , these coordinates described as being fundamental, since they have an unknown substructure, and it is unknown whether or not they are composed of smaller and even more fundamental particles.[113][114] Of central importance is the Standard Model, a theory that is concerned with electromagnetic interactions and the weak and strong nuclear interactions.[115] The Standard Model is supported by the experimental confirmation of the existence of particles that compose matter: quarks and leptons, and their corresponding "antimatter" duals, as well as the force particles that mediate interactions: the photon, the W and Z bosons, and the gluon.[113] The Standard Model predicted the existence of the recently discovered Higgs boson, a particle that is a manifestation of a field within the universe that can endow particles with mass.[116][117] Because of its success in explaining a wide variety of experimental results, the Standard Model is sometimes regarded as a "theory of almost everything".[115] The Standard Model does not, however, accommodate gravity. About 25% of the protons and all the neutrons in the universe, by mass, were converted to helium, with small amounts of deuterium (a form of hydrogen) and traces of lithium. (Apparent image area about 1/79 that of a full moon)[1]Age (within Lambda-CDM model)13.799 ± 0.021 billion years[2]DiameterUnknown.[3] Diameter of the observable universe: 8.8×1026 m (28.5 Gpc or 93 Gly)[4]Mass (ordinary matter)At least 1053 kg[5]Average density (including the contribution from energy)9.9 x 10-30 g/cm3[6]Average temperature2.72548 K (-270.4 °C or -454.8 °F)[7]Main contentsOrdinary (baryonic) matter (26.8%)Dark matter (26.8%)Dark matter (26.8%)Dark matter (26.8%)Dark matter (26.8%)Cort = 454.8 °F)[7]Main contentsOrdinary (baryonic) matter (26.8%)Dark matter (26. The universe (Latin: universus) is all of space and time[a] and their contents, [10] including planets, stars, galaxies, and all other forms of matter and energy. arXiv:astro-ph/0502178. 19, Dover, New York: "The Buddhists denied the existence of substantial matter altogether. The Poincaré conjecture, proved in 2003 by Grigori Perelman, provides that the 3-sphere is the only three-dimensional manifold (up to homeomorphism) with these properties. October 28, 2003. Jeans, J. "To see the Universe in a Grain of Taranaki Sand". 46, Accessed October 7, 2013, "...dark matter: An invisible, essentially collisionless component of matter that makes up about 25 percent of the energy density of the universe... PMC 5256042. J.; Barreiro, R. Physical properties Main articles: Observable universe, and Metric expansion of space Of the four fundamental interactions, gravitation is the dominant at astronomical length scales. The "hot" 3-ball could be thought of as the "lower hemisphere". (July 23, 2013). S2CID 118961123. Thus, S3 as a Lie group is isomorphic to SU(2). "Über die Krümmung des Raumes" (PDF). a big hole". Some physicists have suggested various multiverse hypotheses, in which our universe might be one among many universes that likewise exist.[3][20][21] Part of a series on Physical cosmology Big Bang · Universe Age of the universe Chronology of the universe Early universe Inflation · Nucleosynthesis Backgrounds Gravitational wave (GWB) Microwave (CMB) · Neutrino (CNB) Expansion · Future Hubble's law · Redshift Metric expansion of space FLRW metric · Friedmann equations Inflations Inflation · Nucleosynthesis Backgrounds Gravitational wave (GWB) Microwave (CMB) · Neutrino (CNB) Expansion · Future Hubble's law · Redshift Metric expansion of space FLRW metric · Friedmann equations Inflation · Nucleosynthesis Backgrounds Gravitational wave (GWB) Microwave (CMB) · Neutrino (CNB) Expansion · Future Hubble's law · Redshift Metric expansion of space FLRW metric · Friedmann equations Inflation · Nucleosynthesis Backgrounds Gravitational wave (GWB) Microwave (CMB) · Neutrino (CNB) Expansion · Future Hubble's law · Redshift Metric expansion of space FLRW metric · Friedmann equations Inflation · Nucleosynthesis Backgrounds Gravitational wave (GWB) Microwave (CMB) · Neutrino (CNB) Expansion · Future Hubble's law · Redshift Metric expansion of space FLRW metric · Friedmann equations Inflation · Nucleosynthesis Backgrounds Gravitational wave (GWB) · Neutrino (CNB) Expansion · Future Hubble's law · Redshift Metric expansion of space FLRW metric · Friedmann equations Inflation · Nucleosynthesis Backgrounds Gravitational wave (GWB) · Neutrino (CNB) Expansion · Future Hubble's law · Redshift Metric expansion of space FLRW metric · Friedmann equations Inflation · Nucleosynthesis Backgrounds Gravitational wave (GWB) · Neutrino (CNB) · Neutrino expanding universe Ultimate fate of the universe Components · Structure Components Lambda-CDM model Dark energy · Dark fluid · Dark matter Structure Feionization · Structure formation Experiments Black Hole Initiative (BHI) BOOMERanG Cosmic Background Explorer (COBE) Dark Energy Survey (Illustris project Planck space observatory Sloan Digital Sky Survey (SDSS) 2dF Galaxy Redshift Survey ("2dF") Wilkinson Microwave AnisotropyProbe (WMAP) Scientists Aaronson Alfvén Alpher Bharadwaj Boushaki Copernicus de Sitter Dicke Ehlers Einstein Ellis Friedmann Galileo Gamow Guth Hawking Hubble Kepler Lemaître Mather Newton Penrose Penzias Rubin Schmidt Smoot Suntzeff Sunyaev Tolman Wilson Zeldovich List of cosmologists Subject history of the Big Bang theory Timeline of cosmological theories Category Astronomy portalvte Definition Hubble Space Telescope - Ultra deep field galaxies to Legacy field zoom out(video 00:50; May 2, 2019) The physical universe is defined as all of space and time[a] (collectively referred to as spacetime) and their contents.[10] Such contents comprise all of energy in its various forms, including electromagnetic radiation and matter, and therefore planets, moons, stars, galaxies, and the contents of intergalactic space. [22][23][24] The universe also includes the physical laws that influence energy and matter, such as conservation laws, classical mechanics, and relativity. [25] The universe is often defined as "the totality of existence", or everything that exists, everything that has existed, and everything that will exist. [25] In fact, some philosophers and scientists support the inclusion of ideas and abstract concepts — such as mathematics and logic—in the definition of the universe. [27][28][29] The word universe may also refer to concepts such as the cosmos, the world, and nature. [30][31] Etymology The word universe. derives from the Old French word univers, which in turn derives from the Latin word universum.[32] The Latin word was used by Cicero and later Latin word was used by Cicero and later Latin authors in many of the same senses as the modern English word is used.[33] Synonyms A term for universe among the ancient Greek philosophers from the Latin word was used by Cicero and later Latin authors in many of the same senses as the modern English word is used.[33] Synonyms A term for universe among the ancient Greek philosophers from the Latin word was used by Cicero and Later Latin authors in many of the same senses as the modern English word is used.[33] Synonyms A term for universe among the ancient Greek philosophers from the Latin word was used by Cicero and Later Latin authors in many of the same senses as the modern English word is used.[33] Synonyms A term for universe among the ancient Greek philosophers from the Latin word was used by Cicero and Later Latin authors in many of the same senses as the modern English word is used.[33] Synonyms A term for universe among the ancient Greek philosophers from the Latin word was used by Cicero and Later Latin authors in many of the same senses as the modern English word is used.[33] Synonyms A term for universe among the ancient Greek philosophers from the Latin word was used by Cicero and Later Latin authors in many of the same senses as the modern English word is used.[33] Synonyms A term for universe among the ancient Greek philosophers from the Latin authors in many of the same senses as the modern English word is used.[33] Synonyms A term for universe among the ancient Greek philosopherse from the Latin authors in many of the same senses as the modern English word is used.[33] Synonyms A term for universe among the same senses as the modern English word is used.[33] Synonyms A term for universe among the same senses as the modern English word is used.[33] Synonyms A term for universe among the same senses as the modern English word is used.[33] Synonyms A term for all', defined as all matter and all space, and τὸ ὅλον (tò hólon) 'all things', which did not necessarily include the void.[34][35] Another synonyms are also found in Latin authors (totum, mundus, natura)[37] and survive in modern languages, e.g., the German words Das All, Weltall, and Natur for universe. (eds.). ISBN 978-1-4614-8729-6. It may be embedded in 4-dimensional Euclidean space as the set of points equidistant from a fixed central point. {\\label{l}\_{i,xi\_{1}}} This could also be expressed in R4 as x 0 = cos  $\xi$  1 sin  $\eta$  $x 1 = \sin \xi 1 \sin \eta x 2 = \cos \xi 2 \cos \eta x 3 = \sin \xi 2 \cos \eta$ . doi:10.1086/307221. Principles of Stellar Evolution and Nucleosynthesis. ISBN 978-3-319-06254-9. Lausanne. Other than neutrinos, a form of hot dark matter has not been detected directly, making it one of the greatest mysteries in modern astrophysics. A Livio, Mario (2001). p. 1.
Retrieved August 10, 2006. (part 1): 142-52. For example, radio messages sent from Earth may never reach some regions of space, even if the universe it.[48] The spatial region that can be observed with telescopes is called the observable universe, which depends on the location of the observer. doi:10.1007/BF01332580. Using the Hooker Telescope, Edwin Hubble identified Cepheid variables in several spiral nebulae and Triangulum among others, were entire galaxies outside our own, thus proving that universe consists of a multitude of galaxies.[175] The modern era of physical cosmology began in 1917, when Albert Einstein first applied his general theory of relativity to model the structure and dynamics of the universe. Retrieved 13 September 2021. These were probably very massive, luminous, non metallic and short-lived. {\displaystyle dV=\sin \eta \cos \eta \,d\eta \wedge d\xi \_{1}\wedge d\xi \_{2}.} To get the interlocking circles of the Hopf fibration, make a simple substitution in the equations above[2]  $z 1 = e i (\xi 2 - \xi 1) cos \eta$ . Max Tegmark developed a four-part classification scheme  $(\xi 1 + \xi 2) sin \eta z 2 = e i (\xi 2 - \xi 1) cos \eta$ . Max Tegmark developed a four-part classification scheme  $(\xi 1 + \xi 2) sin \eta z 2 = e i (\xi 2 - \xi 1) cos \eta$ . for the different types of multiverses that scientists have suggested in response to various Physics problems. 't Hooft (1997). While the spatial size of the observable universe, which is approximately 93 billion light-years in diameter at the present day. Retrieved October 31, 2007. Astronomical models of the universe were proposed soon after astronomy began with the Babylonian astronomers, who viewed the universe as a flat disk floating in the ocean, and this forms the premise for early Greek maps like those of Anaximander and Hecataeus of Miletus. arXiv:0801.0006. Weeks, The Shape of Space: How to Visualize Surfaces and Three-dimensional Manifolds, 1985, ([2]) (Chapter 14: The Hypersphere) (Says: A Warning on terminology: Our two-sphere is defined in three-dimensional ball. The model is based on general relativity and on simplifying assumptions such as the homogeneity and isotropy of space. JSTOR 2707516. pp. 223ff. Encyclopædia Britannica. 571: A16. S2CID 9890455. See image to right. A Ryden, Barbara, "Introduction to Cosmology", 2006, eqn. p. 34. One such choice — by no means unique — is to use ( $\psi$ ,  $\theta$ ,  $\varphi$ ), where  $x 0 = r \cos \psi x 1 = r \sin \psi \cos \theta x 2 = r \sin \psi \sin \theta \cos \varphi x 3 = r \sin \psi \sin \theta \sin \varphi$  {\displaystyle {\begin{aligned}} where  $\psi$  and  $\theta$  run over the range 0 to  $\pi$ , and  $\varphi$  runs over 0 to  $2\pi$ . Charles Hartshorne and the Existence of God. The top two rows' columns contain up (u) and down (d) quarks, charm (c) and strange (s) quarks, top (t) and bottom (b) quarks, and photon (g), respectively. S2CID 118910636. doi:10.1126/science.aa4033. A version of the model with a cosmological constant (Lambda) and cold dark matter, known as the Lambda-CDM model, is the simplest model that provides a reasonably good account of various observations about the universe. Bibcode:2007JCAP...01..004P. arXiv:0911.1955. A Greek-English Lexicon. ^ Eliade, Mircea (1964). Bibcode:1999ApJ...517..565P. Bibcode:1999ApJ...577..565P. Bibcode:1999ApJ...577..565P. dimensions is an ordinary sphere (or 2-sphere, a two-dimensional surface), the boundary of a ball in four dimensions is a 3-sphere (an object with three dimensions). Physics 7:Relativity, SpaceTime and Cosmology. doi:10.1007/978-1-4614-8730-2 10. There is in Sānkhya philosophy no separate existence of qualities. arXiv:astro-ph/0403597. Electrons are stable and the most common charged lepton in the universe, whereas muons and taus are unstable particles to form various composite par such as atoms and positronium. (2007). Encyclopaedia Britannica online. Parmenides denoted this reality as τὸ ἐν (The One). ^ Einstein, A (1917). p. 2. Contributions from scalar fields that are constant in space are usually also included in the cosmological constant. Bode's Jahrbuch. Jamil (2001), "Tusi and Copernicus: The Earth's Motion in Context", Science in Context, 14 (1-2): 145-63, doi:10.1017/s0269889701000060, S2CID 145372613 ^ a b Misner, Thorne and Wheeler, pp. 4 (1): 166-173. These coordinates are useful in the description of the 3-sphere as the Hopf bundle S 1  $\rightarrow$  S 3  $\rightarrow$  S 2. Ordinary matter, attracted to these by gravity, formed large gas clouds and eventually, stars and galaxies, where the dark matter was most dense, and voids where it was least dense. ^ Tegmark, Max (2003). doi:10.1016/0370-2693(86)90611-8. The Bowl of Night: The Physical Universe and Scientific Thought. The octonionic structure does give S7 one important property: parallelizability. Living Reviews in Relativity. Fraser Cain. Bibcode:1957RvMP...29..454E. Bibcode:1922ZPhy...10..377F. The remaining two interactions, the weak and strong nuclear forces, decline very rapidly with distance; their effects are confined mainly to sub-atomic length scales. Dark matter gradually gathered, forming a foam-like structure of filaments and voids under the influence of gravity doi:10.1103/RevModPhys.29.454. 319 (6056): 751-53. ISBN 978-1-292-02293-2. Monthly Notices of the Royal Astronomical Society. Though the original text has been lost, a reference in Archimedes' book The Sand Reckoner describes Aristotle responded to these paradoxes by developing the notion of a potential countable infinity, as well as the infinitely divisible continuum. The cosmological constant can be formulated to be equivalent to vacuum energy. The round metric on the 3-sphere in these coordinates is given by d s 2 = d \eta 2 + sin 2 \eta d \xi 1 2 + cos 2 \eta d \xi 2 2 {\displaystyle  $ds^{2}=d eta^{2}+\sin^{2}+cos^{$ the universe. There is an interesting action of the circle group T on S3 giving the 3-sphere the structure of a principal circle bundle known as the Hopf bundle. Kanada believed light as composed of minute particles emitted by substances and striking the eye." ^ Stcherbatsky, F. It started roughly 1 second after the Big Bang, after the majority of hadrons annihilated each other at the end of the hadron epoch. An Introduction to Modern Cosmology (2nd ed.). spacetelescope.org. Physics World. Due to this expansion, scientists on Earth can observe the light from a galaxy 30 billion light-years away even though that light has traveled for only 13 billion years; the very space between them has expanded. A Berardelli, Phil (March 25, 2010). Rings of constant ξ1 and ξ2 above form simple orthogonal grids on the tori. arXiv:gr-qc/0102010v2. ISBN 978-0-7503-0806-9. 47 (12): 1031-1035. Physics of the Impossible: A Scientific Exploration into the World of Phasers, Force Fields, Teleportation, and Time Travel. ISBN 978-0-387-10090-6. De Mundo. European Space Agency. According to Aristotle's physical interpretation of the model, celestial spheres eternally rotate with uniform motion around a stationary Earth. ^ "Planck captures portrait of the young universe, revealing earliest light". "Distances and metallicities for 17 Local Group galaxies". The n-Category Café. "Everything is evanescent",... ^ I. pp. 142, 171. SLAC-PUB-1974. ^ The Compact Edition of the Oxford English Dictionary, volume II, Oxford: Oxford University Press, 1971, p. 75 (2): 559-606. Retrieved February 1, 2018. Spacetime Main articles: Spacetime and World line See also: Lorentz transformation Spacetimes are the arenas in which all physical events take place. "What is a light-year?". Chinese Science. p. 220. Reprinted as Appendix I in Dickson FP (1969). This unseen matter is known as dark matter[17] (dark means that there is a wide range of strong indirect evidence that it exists, but we have not yet detected it directly). p. 43. ISBN 978-0-470-84835-7.. However, advances in experimental techniques have
revealed other previously theoretical phases, such as Bose-Einstein condensates and fermionic condensates. Edwin Hubble, the discoverer of the big bang universe. By analogy, an infinite plane has zero curvature but infinite area, whereas an infinite cylinder is finite in one direction and a torus is finite in both. Bibcode:2017Natur.550..371S. If k=1, the curvature is often visualized as a three-dimensional sphere embedded in a four-dimensional space. 2012. ^ Silk, Joseph (2009). Harper Perennial. The photon epoch, about 10 seconds after most leptons and anti-leptons were annihilated at the end of the lepton epoch, about 10 seconds after the Big Bang. Stereographic coordinates Can be obtained via stereographic projection of S3 from a pole onto the corresponding equatorial R3 hyperplane. 757. See also 1-sphere, 2-sphere, n-sphere tesseract, polychoron, simplex Pauli matrices rotation group SO(3) quaternions and spatial rotations Hopf bundle, Riemann sphere Poincaré sphere Reeb foliation Clifford torus References ^ Georges Lemaître (1948) "Quaternions et espace elliptique", Acta Pontifical Academy of Sciences 12:57-78 ^ Banchoff, Thomas. Returning to our picture of the unit two-sphere sitting on the Euclidean plane: Consider a geodesic in the two-sphere of the same length, based at the origin, and map this to a geodesic in the two-sphere of the same length. "Earth's new address: 'Solar System, Milky Way, Laniakea'". Cambridge, MA: M.I.T. Press. ^ Harari H. 527-29) ^ Bartel (1987, pp. Further observational improvements led to the realization that the Sun is one of hundreds of billions of stars in the Milky Way, which is one of a few hundred billion galaxies in the universe. S2CID 119067072. Retrieved May 1, 2011. pp. 279-294. Any topological space with these homology groups is known as a homology 3-sphere. The other 75% of the protons remained unaffected, as hydrogen nuclei. "CI301: The Anthropic Principle". TalkOrigins Archive. ^ Aurich, Ralf; Lustig, S.; Steiner, F.; Then, H. Misner; C.W.; Thorne; Kip; Wheeler; J.A. (1973). livescience. However, present observations cannot exclude the possibilities that the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The spacetime of the universe has more dimensional spaces.[68][69] The universe has more dimensional spaces.[68][69] The universe has more dimensional spaces.[68][69] The universe has mo is usually interpreted from a Euclidean perspective, with space as consisting of three dimensions, and time as consisting of one dimension. [70] By combining space and time into a single manifold called Minkowski space, physicists have simplified a large number of physical theories, as well as described in a more uniform way the workings of the universe at both the supergalactic and subatomic levels. Penguin Group. {\displaystyle U=\exp \left(\sum \_{i=1}^{3}\alpha \_{i}J\_{i}\right).} [3] The condition that the determinant of U is +1 implies that the coefficients at both the supergalactic and subatomic levels. Penguin Group. {\displaystyle U=\exp \left(\sum \_{i=1}^{3} \alpha \_{i}J\_{i}\right).} [3] The condition that the determinant of U is +1 implies that the coefficients at both the supergalactic and subatomic levels. Penguin Group. {\displaystyle U=\exp \left(\sum \_{i=1}^{3} \alpha \_{i}J\_{i}\right).} [3] The condition that the determinant of U is +1 implies that the coefficients at both the supergalactic and subatomic levels. Penguin Group. {\displaystyle U=\exp \left(\sum \_{i=1}^{3} \alpha \_{i}J\_{i}\ (s) = 0 \ (s) are constrained to lie on a 3-sphere. ISBN 978-0-7674-1957-4. S2CID 123472763.Linde A. Retrieved August 20, 2015. ^ a b Misner, Thorne and Wheeler, p. ^ Mandolesi, N.; Calzolari, P.; Sironi, G.; Inzani, P.; Sironi, G.; Solheim, J.-E.; Berger, L.; Partridge, R.B.; Martenis, P.L.; Sangree, C.H.; Harvey, R.C. (1986). 641: A6 Dark matter neither emits nor absorbs light or any other electromagnetic radiation at any significant level. One can even find three linearly independent and nonvanishing vector fields. {\displaystyle S^{3}=\left\{q\in \mathbb {H} :\|q\|=1\right\}.} This description as the quaternions of norm one identifies the 3-sphere with the versors in the quaternion division ring. Universe The Hubble Ultra-Deep Field image shows some of the most remote galaxies visible with present technology, each consisting of billions of stars. The inverse of this map takes p to v = 1 1 - x 0 (x 1, x 2, x 3). This is the common account as you have heard from astronomers. Philosophical Transactions of the Royal Society A. ^ G. B.; Bartolo, N.; Basak, S. Scalar fields having only a slight amount of spatial inhomogeneity would be difficult to distinguish from a cosmological constant. These are called, respectively, the flat, open and closed universes.[73] Observations, including the Cosmic Background Explorer (COBE), Wilkinson Microwave Anisotropy Probe (WMAP), and Planck maps of the CMB, suggest that the universe is infinite in extent with a finite age, as described by the Friedmann-Lemaître-Robertson-Walker (FLRW) models [74][68][75][76] These FLRW models thus support inflationary models and the standard model of cosmology, describing a flat, homogeneous universe presently dominated by dark matter and dark energy.[77][78] Support of life Main article: Fine-tuned universe may be fine-tuned; the Fine-tuned universe hypothesis is the proposition that the conditions that allow the existence of observable life in the universe can only occur when certain universal fundamental physical constants lie within a very narrow range of values, so that if any of several fundamental constants were only slightly different, the universe would have been unlikely to be conducive to the establishment and development of matter, astronomical structures, elemental diversity, or life as it is understood.[79] The proposition is discussed among philosophers, scientists, theologians, and proponents of creationism. For who would place this lamp of a very beautiful temple in another or better place than this wherefrom it can illuminate everything at the same time?— Nicolaus Copernicus, in Chapter 10, Book 1 of De Revolutionibus Orbium Coelestrum (1543) As noted by Copernicus himself, the notion that the Earth rotates is very old dating at least to Philolaus (c. S2CID 124323774. "A century of general relativity: Astrophysics and cosmology". ^ Close, Frank (2012). ^ Isaak, Mark, ed. Annals of the New York Academy of Sciences. Pearson. JSTOR 595168. arXiv:1303.5076. www.learner.org. "Universe Should Not Actually Exist: Big Bang Produced Equal Amounts Of Matter And Antimatter". In this diagram, time passes from left to right, so at any given time, the universe is represented by a disk-shaped "slice" of the diagram The initial hot, dense state is called the Planck epoch, a brief period extending from time zero to one Planck time unit of approximately 10-43 seconds. Theoria: An International Journal for Theory History and Foundations of Science. Dark energy, which is the energy of empty space and is causing the expansion of the universe to accelerate, accounts for the remaining 68.3% of the contents.[8][86][87] The formation of clusters and large-scale filaments in the cold dark matter model with dark energy. doi:10.1119/1.11968. Bibcode:2016A&A...594A..13P. Universe Today. According to this theory, space and time emerged together 13.787±0.020 billion years ago,[11] and the universe has been expanding ever since. Creation Myths of the World. Merriam-Webster Dictionary. Timothy Ferris. The frames show the evolution of structures in a 43 million parsecs (or 140 million) light-years) box from redshift of 30 to the present epoch (upper left z=30 to lower right z=0). ^ "Physics 7:Relativity, SpaceTime and Cosmology" (PDF). Retrieved August 23, 2015. pp. 447-. the heliocentrical astronomy invented by Aristarchos of Samos and still defended a century later by Seleucos the Babylonian ^ William P. 75 (3): 166-73 (169). the Chaldaean Seleucus from Seleucia ^ Sarton, George (1955). ^ a b Bars, Itzhak; Terning, John (October 19, 2018). ^ a b c "First Planck results: the universe is still weird and interesting". arXiv:1301.5295. ^ Marov, Mikhail Ya. (2015). 8 (3): 836-854. Retrieved October 26, 2017. &
Bromm, Volker (March 2002). arXiv:0704.0646. National Geographic. The Euclidean metric on R4 induces a metric on the 3-sphere giving it the structure of a Riemannian manifold. Like all elementary particles, photons are currently best explained by quantum mechanics and exhibit wave-particle duality, exhibiting properties of waves and of particles. In particular, they noted the ability of matter to change forms (e.g., ice to water to steam) and several philosophers proposed that all the physical materials in the world are different forms of a single primordial material, or arche. TechTimes.com. Particles and Fundamental Interactions: An Introduction to Particle Physics (2nd ed.). doi:10.1086/300499. Observationally, the universe appears to be flat (k = 0), with an overall density that is very close to the critical value between recollapse and eternal expansion.[135] Multiverse hypothesis Main articles: Multiv disconnected universes, collectively denoted as the multiverse, challenging or enhancing more limited definitions of the universe.[20][136] Scientific multiverse and simulated reality. Later Greek philosophers, observing the motions of the heavenly bodies, were concerned with developing models of the universe-based more profoundly on empirical evidence. "Shut up and calculate". "The cosmological constant". Centre for Astrophysics and Supercomputing. Bibcode: 2020A&A...641A...6P. ^ "Content of the Universe - WMAP 9yr Pie Chart". Vol. 2 (revised 4th English ed.). When q is used to describe spatial rotations (cf. "Spacetime and Euclidean geometry". 54. S2CID 4349689. Archived from the original on March 10, 2010. Retrieved from "Between the larger structures are voids, which are typically 10-150 Mpc (33 million-490 million ly) in diameter. Writing in the American Journal of Physics, [4] Mark A. "Why the cosmological constant is small and positive". ISBN 978-0-03-006228-5. Dark matter Main article: Dark matter in the universe. Giant clouds of hydrogen and helium were gradually drawn to the places where dark matter was most dense, forming the first galaxies, stars, and everything else seen today. Cham. A Latin Dictionary. His hypotheses are that the fixed stars and the Sun remain unmoved, that the sphere of fixed stars, situated about the same center as the Sun, is so great that the circle in which he supposes the Earth to revolve bears such a proportion to the distance of the fixed stars as the center of the sphere bears to its surface Aristarchus thus believed the stars to be very far away, and saw this as the reason why stellar parallax had not been observed, that is, the stars had not been observed to move relative each other as the Earth moved around the Sun. Dark matter is estimated to constitute 26.8% of the total mass-energy and 84.5% of the total matter in the universe is ordinary matter, that is, atoms, ions, electrons and the objects they form. ^ Smorra C.; et al. If the universe were sufficiently dense, k would equal +1, meaning that its average curvature throughout is positive and the universe in a Big Bounce. ProfMattStrassler.com. For unit radius another choice of hyperspherical coordinates, (η, ξ1, ξ2), makes use of the embedding of S3 in C2. "Does the Multiverse Really Exist?". (1922). There is no point in considering one without the other.[15] The universe appears to be a smooth spacetime of the physical universe can therefore be identified by a set of four coordinates: (x, y, z, t). Hopf coordinates The Hopf fibration can be visualized using a stereographic projection of S3 to R3 and then compressing R3 to a ball. Retrieved August 21, 2015. S2CID 119522151.McConnachie, A.W.; Irwin, M.J.; Ferguson, A.M.N.; Ibata, R.A.; Lewis, G.F.; Tanvir, N. ISBN 978-0-521-57883-7. "Large-scale homogeneity of the universe measured by the microwave background". The scale of length increases exponentially toward the right. Bibcode: 1986Natur. 319..751M. Vision and Visual Perception. Bibcode: 2003Natur. 425..593L. Jordi; F. it's a different kind of particle... {\displaystyle {\begin{aligned}z {1}&=e^{i\,(xi {1}+xi {2})}\sin \eta \\z {2}&=e^{i\,(xi {2})} \sin \\z {2}&=e^{i\,(xi {2})} \si \xi {1}}\cos \eta .\end{aligned}} In this case η, and ξ1 specify which circle, and ξ2 specifies the position along each circle. The Guardian. Malik Library. 288 (5): 40-51. February 28, 2006. ISBN 978-0-7566-9841-6. The bottom two rows' columns contain electron neutrino (νe) and electron (e), muon neutrino (νμ) and muon (μ), tau neutrino (ντ) and tau (τ), and the Z0 and W± carriers of the weak force. 196. Of the hadrons, protons are stable, and neutrons bound within atomic nuclei are stable. ^ Lewis, C.T. and Short, S (1879) A Latin Dictionary, Oxford University Press, ISBN 0-19-864201-6, pp. Columns are three generations of matter (fermions) and one of forces (bosons). Eric Chaisson. 125 (1): 189-99. Since the Big Bang, the universe has expanded monotonically. XIII. This image shows points on S2 and their corresponding fibers with the same color. Harvard Smithsonian Center for Astrophysics. "Size of the Milky Way Upgraded, Solving Galaxy Puzzle". Science. pp. 93-102. "The Cosmological Argument". Retrieved August 11, 2015. Bibcode:1999ASIC..541..117L. In particular, the curvature of spacetime is directly related to the energy and momentum of whatever matter and radiation are present. ^ Riess, Adam G.; Filippenko; Challis; Clocchiatti; Diercks; Garnavich; Gilliland; Hogan; Jha; Kirshner; Leibundgut; Phillips; Reiss; Schmidt; Schommer; Smith; Spyromilio; Stubbs; Suntzeff; Tonry (1998). "Weird! Our Universe May Be a 'Multiverse,' Scientists Say". PMID 21827123. ^ Bolonkin, Alexander (November 2011). Harvard-Smithsonian Center for Astrophysics Annenberg Learner. Bibcode: 2004biba.book.....S. Journal of Computational Design and Engineering. The entire collection of these separate spacetimes is denoted as the multiverse.[20] With this terminology, different universes are not causally connected to each other.[20] In principle, the other unconnected universes may have different dimensionalities and topologies of spacetime, different forms of matter and energy, and different forms of matter and energy. purely speculative.[20] Others consider each of several bubbles created as part of chaotic inflation to be separate universes, though in this model these universes, though in this model these universes, though in this model these universes all share a causal origin.[20] Historical conceptions See also: Cosmology, Timeline of cosmology, Timeli Mathematica § Beginnings of the Scientific Revolution Historically, there have been many ideas of the cosmos (cosmologies) and its origin (cosmogonies). In this picture, the whole 3D space maps the surface of the hypersphere. Big Bang nucleosynthesis shut down after about 20 minutes due to the rapid drop in temperature and density of the expanding universe. pp. 24-. Archimedes wrote: You, King Gelon, are aware the universe is the name given by most astronomers to the sphere the center of which is the center of the Earth, while its radius is equal to the straight line between the center of the Sun and the center of the Earth. What this means, in the broad sense, is that any loop, or circular path, on the 3-sphere. ISBN 978-0-19-864201-5. "The Structure of the Universe". This view of the 3-sphere is the basis for the study of elliptic space as developed by Georges Lemaître [1] Properties Elementary properties The 3-dimensional surface volume of a 3-sphere of radius r is  $SV = 2 \pi 2 r 3$  (displaystyle  $SV=2|pi^{2}r^{3}|$ ), while the 4-dimensional hypervolume (the content of the 4-dimensional hypervolume (the content of the 4-dimensional hypervolume) is  $H = 1 2 \pi 2 r 4$ . 2. David (2004). Davies, Paul (2006). The stretching of space also accounts for the apparent paradox that two galaxies can be 40 billion light-years apart, although they started from the same point 13.8 billion years ago[131] and never moved faster than the speed of light. (1983). "Universe 101: Will the Universe expand forever?". 4 (1): 1. Reprinted as Appendix II in Dickson FP (1969). "The First Stars in the Universe". Foundations of Physics. arXiv:1101.5476. "Applications of Bayesian model averaging to the curvature and size of the Universe". In literature In Edwin Abbott's Flatland, published in 1884, and in Sphereland, a 1965 sequel to Flatland by Dionys Burger, the 3-sphere is referred to as an oversphere, and a 4-sphere is referred to as a hypersphere. 38 (4): 643-51. The modern era of cosmology began with Albert Einstein's 1915 general theory of relativity, which made it possible to quantitatively predict the origin, evolution, and conclusion of the universe as a whole. (1993) [1964]. Baker Academic. As a 3-dimensional manifold one should be able to parameterize S3 by three coordinates, just as one can parameterize the 2-sphere using two coordinates (such as latitude and longitude). ^ Onyisi, P. ISBN 978-94-007-2463-1. arXiv:astro-ph/0410489. An important parameter determining the future evolution of the universe divided by a critical value of that density. All of space and time and their contents For other uses, see Universe ( $\sum i = 1.3 \alpha i J i$ ). ^ Lipscomb, Stephen (2014). The relation is specified by the Einstein field equations, a system of partial differential equations. ISBN 978-0-553-05340-1. (2001). ^ Perlmutter, S.; Aldering; Goldhaber; Knop; Nugent; Castro; Deustua; Fabbro; Goobar; Groom; Hook; Kim; Kim; Lee; Nunes; Pain; Pennypacker; Quimby; Lidman; Ellis; Irwin; McMahon; Ruiz-Lapuente; Walton; Schaefer; Boyle; Filippenko; Matheson; Fruchter; et al. ^ Howell, Elizabeth (March 20, 2018). Most modern, accepted theories of cosmology are based on general relativity and, more specifically, the predicted Big Bang.[146] Mythologies Main articles: Creation myth, Cosmogony, and Religious cosmology Many cultures have stories describing the origin of the world and universe. It is also simply connected.
Bibcode:1998AJ....116.1009R. The set of unit quaternions is then given by matrices of the above form with unit determinant. doi:10.1098/rsta.1902.0012. ^ a b Hawking, Stephen (1988). National Aeronautics and Space Administration. 534-7) ^ Nasr, Seyyed H. Wightman (1951, 1953), The Growth of Scientific Ideas, Yale University Press p. Physics Today. The boundary of a 3-ball is a 2sphere, and these two 2-spheres are to be identified. Bibcode:1986PhLB..175..395L. doi:10.1051/0004-6361/201833910. or, more precisely, dynamic entities, although they are also called dharmas ('qualities')." ^ Donald Wayne Viney (1985). arXiv:astro-ph/0004075. Tegmark and others[139] have argued that, if space is infinite, or sufficiently large and uniform, identical instances of the history of Earth's entire Hubble volume occur every so often, simply by chance. "Urban Myths in Contemporary Cosmology," Philosophy, Physics (Aristotle), Hindu cosmology, Islamic cosmology, and Philosophy of space and time The pre-Socratic Greek philosophers and Indian philosophers developed some of the earliest philosophical concepts of the universe. [13][151] The earliest greek philosophers noted that appearances can be deceiving, and sought to understand the underlying reality behind the appearances can be deceiving. relation of Inference uniting them. "Parallel Universes". H. Location of the Earth in the Universe EarthSolar SystemRadcliffe WaveOrion ArmMilky WayLocal GroupVirgo SCILaniakea SCIOur Universe See also Chronology of the universe Cosmic Calendar (scaled down timeline) Cosmic latte Cosmos Detailed logarithmic timeline Earth's location in the universe False vacuum Future of an expanding universe Galaxy And Mass Assembly survey Heat death of the universe History of the center of the Universe Non-standard cosmology Nucleocosmochronology Panspermia Rare Earth hypothesis Religious cosmology Space and survival Terasecond and longer Timeline of the early universe Timeline of the far future Zero-energy universe References Footnotes ^ a b According to modern physics, particularly the theory of relativity, space and time are intrinsically linked as spacetime. doi:10.12942/Irr-2001-1. At the largest scale, galaxies are distributed uniformly and the same in all directions, meaning that the universe has neither an edge nor a center. ^ "New Horizons spacecraft answers the question: How dark is space?". ^ Clayton, Donald D. General Relativity and Gravitation. Retrieved January 8, 2013. Neutrinos stream throughout the universe but rarely interact with normal matter, [123] The lepton epoch was the period in the evolution of the early universe in which the leptons dominated the mass of the universe. S2CID 14178620. G. ^ Everett, Hugh (1957). {\displaystyle x {1}+x {2}i+x {3}i+x {4}\x {3}+ix {4}\x {3}+ix {4}\x {3}+ix {4}\x {3}+ix {4}\x {3}+ix {4}\x {3}+ix {4}-ix {2}i+x {3}i+x {4}-ix {4}-ix {3}i+x {4}-ix {4 gives an injective algebra homomorphism from H to the set of 2 × 2 complex matrices. doi:10.1038/scientificamerican0503-40. "Three generations of quarks and leptons" (PDF). It is often attributed to "dark energy", an unknown form of energy that is hypothesized to permeate space.[103] On a mass-energy equivalence basis, the density of dark energy ( $\sim 7 \times 10-30$  g/cm3) is much less than the density of ordinary matter or dark matter within galaxies. {\displaystyle dV=r^{3}\left(\sin ^{2}\psi \,\sin \theta \right), d\psi \wedge d\theta \seque d\theta \se Atomic nuclei were created in the process of nucleosynthesis which occurred during the first few minutes of the photon epoch. Tegmark calculated that our nearest so-called doppelgänger, is 1010115 metres away from us (a double exponential function larger than a googolplex).[140][141] However, the arguments used are of speculative nature.[142] Additionally, it would be impossible to scientifically verify the existence of an identical Hubble volume. p. 170. πας ^ Liddell; Scott. (2005). ^ a b NASA/WMAP Science Team (January 24, 2014). ^ Landau & Lifshitz (1975, p. 361): "It is interesting to note that in a closed space the total electric charge must be zero. Because most of the mass of an atom is concentrated in its nucleus, which is made up of baryonic matter to describe ordinary matter, although a small fraction of this "baryonic matter" is electrons. That is, imagine a pair of 3-balls of the same size, then superpose them so that their 2-spherical boundaries match, and let matching pairs of points on the pair of 2-spheres be identically equivalent to each other. It is the basis of current cosmological models of the universe. Retrieved January 4, 2014. Bibcode: 2014A&A...571A..16P. (2003). "A Greek-English Lexicon". Facts and Mysteries in Elementary Particle Physics. says the Buddhist, because there is no stuff... It may seem that this conclusion is uncertain because it is based on the questionable assumptions of perfect homogeneity and isotropy (the cosmological principle) and that only the gravitational interaction is significant. External links Weisstein, Eric W. Retrieved June 9, 2015. Vol. II. doi:10.1007/BF00643984. ^ Dold-Samplonius, Yvonne (2002). 175 (4): 395-400. Nature (Submitted manuscript). Young, Louise. ^ Misner, Thorne and Wheeler, p. (1986). ^ Linde A. 111.. Trotta, J. Again one may think of the third dimension as temperature. {\displaystyle {\begin{pmatrix}e^{i\\xi\_{2}}\cos \eta \\-e^{-i\,xi} {2}\cos \eta &e^{-i,\xi {1}}\sin \eta \end{pmatrix}}. Another way to state this result is if we express the matrix representation of an element of SU(2) as a exponential of a linear combination of the Pauli matrices. ISBN 978-0-521-57598-0. A few minutes later, in a process known as Big Bang nucleosynthesis, nuclei formed from the primordial protons and neutrons. ^ Raine & Thomas (2001, pp. 122-23) ^ a b Raine & Thomas (2001, p. 70) ^ Raine & Thomas (2001, p. 84) coordinates of the 3-ball, perhaps considered to be "temperature". The Classical Theory of Fields (Course of Theoretical Physics). "Planck 2018 results: VI. It is possible to conceive of disconnected spacetimes, each existing but unable to interact with one another.[140][143] An easily visualized metaphor of this concept is a group of separate soap bubbles, in which observers living on one soap bubble cannot interact with those on other soap bubbles, even in principle.[144] According to one common terminology, each "soap bubble" of spacetime is denoted as a universe, whereas our particular spacetime is denoted as the universe, [20] just as we call our moon the Moon. ^ Planck Collaboration; Aghanim, N.; Akrami, Y.; Ashdown, M.; Aumont, J.; Balardini, M.; Banday, A. Citations ^ "Hubble sees galaxies galore". All curves that intersect (0,0,0,1) have infinite radius (= straight line). An Introduction to Islamic Cosmological Doctrines (2nd ed.). The round metric on the 3-sphere in these coordinates is given by[citation needed] ds 2 = r 2 [ d  $\psi$  2 + sin 2  $\psi$  (d  $\theta$  2 + s various types of subatomic particles were able to form in short periods of time known as the quark epoch, the hadron epoch, and the lepton epoch, and the lepton epoch. General Relativity: The Essentials. Bibcode: 2005MNRAS.356..979M. See polar decomposition of a quaternion for details of this development of the three-sphere. ^ Neugebauer, Otto E. "A parts-per-billion measurement of the antiproton magnetic moment" (PDF). Retrieved April 30, 2017. Let a pair of disks be of the same diameter. ^ Peebles, P.J.E. & Ratra, Bharat (2003). ^ Jaume Garriga, Alexander Vilenkin (2007). (1999). Bibcode: 2004PhT....57e..10M. p. xvii. The ACDM model is the most widely accepted model of the universe. Archway Publishing. 29 (3): 361. Institute of Physics Publishing. In this interpretation, parallel worlds are generated in a manner similar to quantum superposition and decoherence, with all states of the wave functions being realized in separate worlds. "The Mathematical Universe". To every new unit of quality corresponds a subtle quantum of matter which is called guna, "quality", but represents a subtle substantive entity. (October 20, 2017). 38, where Wightman calls him Seleukos the Chaldean. When R changes, all the spatial distances in the universe change in tandem; there is an overall expansion or contraction of space itself. ^ Strassler, M. ^ "Unveiling the Secret of a Virgo Dwarf Galaxy". However, if the universe contained too little matter then the self-gravity would be too weak for astronomical structures, like galaxies or planets, to form. The effects of this force are easily observable at the microscopic level because the photon has zero rest mass; this allows long distance interactions. 756. ESO: 12. IOP Publishing. New York Times. Definition In coordinates, a 3-sphere with center (C0, C1, C2, C3) and radius r is the set of all points (x0, x1, x2, x3) in real, 4-dimensional space (R4) such that  $\sum i = 0.3$  (xi - Ci) 2 + (x 2 - C2) 2 + (x 3 - C3) 2 = r 2. Note that the interiors of the 3-balls are not glued to each other. hdl:10486/664735. The existence and properties of dark matter are inferred from its gravitational effects on visible matter, radiation, and the large-scale structure of the universe. "A 'Cosmic Jerk' That Reversed the Universe". ^ Tegmark, Max (2008). It has the property that the absolute value of a quaternion q is equal to the square root of the determinant of the matrix image of q. pp. 1175, 1189-90, 1881-82. In general relativity, the distribution of matter and energy determines the geometry of spacetime, which in turn describes the acceleration of matter. This initial period of inflation is believed to explain why space appears to be very flat, and much larger than light could travel since the start of the universe. [clarification needed] Within the first fraction of a second of the universe's existence, the four fundamental forces had separated. Lett. "The Heliocentric System in Greek, Persian and Hindu Astronomy". Berlin. Retrieved April
16, 2015. Knopf. p. 43ff. ^ a b Luminet, Jean-Philippe (October 9, 2003). p. 6. During the lepton epoch the temperature of the universe was still high enough to create lepton/anti-lepton pairs, so leptons and anti-lepton series, so leptons and anti-lepton series and anti-lepton pairs, so leptons and anti-lepton series and anti-lepton series and anti-lepton pairs, so leptons and anti-lepton series ("decoupled") when these atoms formed can still be seen today; they form the cosmic microwave background (CMB). In 1998, the deceleration parameter was measured by two different groups to be negative, approximately -0.55, which technically implies that the second derivative of the cosmic scale factor a " {\displaystyle {\dot {a}}} has been positive in the last 5-6 billion years.[16][65] This acceleration does not, however, imply that the Hubble parameter is currently increasing; see deceleration parameter for details. ^ Staff (2019). The topology or geometry of the universe includes both local geometry in the observable universe and global geometry. Bibcode:2015Sci...347.1103B. "Astronomers discover largest known structure in the universe is ... Under this map all points of the circle of radius π are sent to the north pole. ὅλος ^ Liddell; Scott A.; McClure, Michael (2004). Just as the unit circle is important for planar polar coordinates, so the 3-sphere is important in the polar view of 4-space involved in quaternion multiplication. Oerter (2006). Neutrinos rarely interact with anything, and are consequently rarely observed. (Note that the numerator and denominator commute here even though quaternionic multiplication is generally noncommutative). doi:10.1038/319751a0. ^ Rindler, p. An atom consists of an atomic nucleus, made up of protons and neutrons, and electrons that orbit the nucleus. De Mundo (composed before 250 BC or between 350 and 200 BC), stated, "Five elements, situated in spheres in five regions, the less being in each case surrounded by the greater—namely, earth surrounded by water, water by air, air by fire, and fire by ether-make up the whole universe".[155] This model was also refined by Callippus and after concentric spheres were abandoned, it was brought into nearly perfect agreement with astronomical observations by Ptolemy. Templeton Pressr. 413 (1): L91-L95. "Eternally existing self-reproducing chaotic inflationary Universe" (PDF). World Scientific. Cosmological parameters". ISBN 978-0-7914-1515-3. Archived from the original on February 2, 1999. ^ P. 10 (1): 377-86. The rejection of the Moon): Cleanthes [a contemporary of Aristarchus and head of the Stoics] thought it was the duty of the Greeks to indict Aristarchus of Samos on the charge of impiety for putting in motion the Hearth], ... ^ Liddell; Scott. There are about 1082 atoms in the observable universe [i.e. the Earth], ... ^ Liddell; Scott. There are about 1082 atoms in the observable universe [i.e. the Earth], ... ^ Liddell; Scott. There are about 1082 atoms in the observable universe - LiveScience, July 2021. Much of the interesting geometry of the 3-sphere stems from the fact that the 3-sphere has a natural Lie group structure given by quaternion multiplication (see the section below on group structure). ISBN 978-981-238-149-1. During the Planck epoch, all types of matter and all types

known forces—is believed to have been as strong as the other fundamental forces, and all the forces may have been unified. Brown loops indicate which fermions (purple and green). Theories of an impersonal universe governed by physical laws were first proposed by the Greeks and Indians.[13] Ancient Chinese philosophy encompassed the notion of the universe including both all of space and all of time. [145] Over the centuries, improvements in astronomical observations of the universe. The same applies to early Buddhism where all qualities are substantive... ^ Liddle, Andrew (2003). ^ Christian, Eric; Samar, Safi-Harb. ^ Peterson, Mark A. One-point compactification After removing a single point from the 2-sphere, what remains is homeomorphic to the Euclidean plane. arXiv:1502.01589. (2015). in reference to David Mermin's famous quote "shut up and calculate!"[26] ^ Holt, Jim (2012). (Notice that, since stereographic projection is conformal, round spheres are sent to round spheres or to planes.) A somewhat different way to think of the one-point compactification is via the exponential map. University of California Riverside. "The baryon content of the universe". The Aristotelian model was accepted in the Western world for roughly two millennia, until Copernicus revived Aristarchus's perspective that the astronomical data could be explained more plausibly if the Earth rotated on its axis and if the Sun were placed at the center of the universe. Subsequent formation of heavier elements resulted from stellar nucleosynthesis. [111] Particles Standard model of elementary particles: the 12 fundamental fermions and 4 fundamental bosons. Ordinary matter is composed of two types of elementary particles: quarks and one down quark; the neutron is formed of two down quarks and one down quark; the neutron is formed of two types of this level are composed by distant spacetime events "in our own universe". This nucleosynthesis formed lighter elements, those with small atomic number. κόσμος ^ Lewis, C.T.; Short, S (1879). The Christian philosopher, John Philoponus, presented the philosophical arguments against the ancient Greek notion of an infinite past and future. (September 2020). Unlike the eternal and unchanging cycles of time, he believed that the world is bounded by the celestial spheres and that cumulative stellar magnitude is only finitely multiplicative. Medieval Science Technology and Medicine: An Encyclopedia. (2008). doi:10.1387/theoria.9951. Astronomy & Astrophysics. From China to Paris: 2000 Years Transmission of Mathematical Ideas. Many of the stars in a galaxy have planets. Cosmological inflation and large-scale structure. Bibcode:1986MPLA....1...81L. Both systems [Sānkhya, and later Indian Buddhism] share in common a tendency to push the analysis of existence up to its minutest, last elements which are imagined as absolute qualities, or things possessing only one unique quality. doi:10.1051/0004-6361/201525830. ISBN 978-0-521-88705-2. ^ Persic, Massimo; Salucci, Paolo (September 1, 1992). ^ "Cosmic Detectives". 500 (1): 525-45. doi:10.1103/RevModPhys.75.559.  $(\frac{1}{x {2}}, {3})$  (b) (1, 0, 0, 0), in which case the point p is given by  $p = (-1 + \|v\|^2) = -1 + v 1 + v (\frac{1}{x {2}}, {3})$ 637X/707/2/916. If one thinks of S3 as a subset of C2, the action is given by (z 1, z 2) ·  $\lambda = (z 1 \lambda, z 2 \lambda) \forall \lambda \in T$  {\displaystyle (z {1}, z {2})\cdot \lambda \in \mathbb {T} }. (October 23, 2012). ISBN 978-0-226-10953-4. Edward Guinan (2005). About 380,000 years after the Big Bang, the temperature of the Universe fell to the point where nuclei could combine with electrons to create neutral atoms. Note that the transition function between these two charts on their overlap is given by v = 1 || u || 2 u {\displaystyle \mathbf {v} = {\frac {1}{\|u\|^{2}}} mathbf {u} } and vice versa. ^ Alī, Ema Akabara. S2CID 30364122. ISBN 978-3 319-19201-7. ^ a b c d Zeilik, Michael; Gregory, Stephen A. Retrieved October 19, 2018. ^ Olbers HWM (1826). In common usage the word 'myth' refers to narratives or beliefs that are untrue or merely fanciful; the stories that make up national or ethnic mythologies describe characters and events that common sense and experience tell us are impossible. April 18, 2007. ISBN 978-1-4808-1294-9. New York: Pergamon Press. Allen & Unwin. ISBN 978-0-7167-0344-0. "electromagnetic radiation | physics". Retrieved November 28, 2011. S2CID 119217397. C. S2CID 123344693. A First Course in General Relativity (2 ed.). First Mariner Books. doi:10.1038/nature.2014.15819. Reviews of Modern Physics. ^ Overbye, Dennis (October 11, 2003). Retrieved September 28, 2006. Initially Poincaré conjectured that all homology 3-spheres are homeomorphic one, now known as the Poincaré homology sphere. Monthly Notices of the Royal Astronomical Society: Letters. Empedocles proposed the elements to be earth, water, air and fire. Creation Out of Nothing: A Biblical, Philosophical, and Scientific Exploration. Proceedings of Cosmology School held at Cargese, Corsica, August 1998. 529-34) ^ Bartel (1987, pp. ^ a b R. ^ (Henry Gravrand, "La civilisation Sereer -Pangool") [in] Universität Frankfurt am Main, Frobenius-Institut, Deutsche Gesellschaft für Kulturmorphologie, Frobenius Gesellschaft, "Paideuma: Mitteilungen zur Kulturkunde, Volumes 43-44", F. Retrieved June 6, 2015. Horizons of Cosmology. This matter includes stars, which produce nearly all of the light we see from galaxies, as well as interstellar gas in the interstellar and intergalactic media, planets, and all the objects from everyday life that we can bump into, touch or squeeze.[108] As a matter of fact, the great majority of ordinary matter in the universe is unseen, since visible stars and gas inside galaxies and clusters account for less than 10 per cent of the ordinary matter contribution to the mass-energy density of the universe.[109] Ordinary matter commonly exists in four states (or phases): solid, liquid, gas, and plasma. This marked the end of the radiation-dominated era and the start of the matter-dominated era. Bibcode:2005ApJ...635L..37R. Gravity's effects are cumulative; by contrast, the effects of positive and negative charges tend to cancel one another, making electromagnetism relatively insignificant on astronomical length scales. 347 (3): 921-36. Effectively, in the many-worlds interpretation the multiverse evolves as a universal wavefunction. Therefore the flux of the electric field through this surface is equal, on the one hand, to the total charge located in the interior of the surface, and on the other hand to the total charge outside of it, with opposite sign. McGraw-Hill. Archived from the original on September 7, 2015. "How large is the Milky Way?". Retrieved February 17, 2015. Conversely, if k is zero or negative, the universe has an infinite volume.[133] It may seem counter-intuitive that an infinite vo in a single instant at the Big Bang when R=0, but exactly that is predicted mathematically when k does not equal 1. ^ a b Allday, Jonathan (2002). April 2, 2013. Seleucus was the first to state that the tides are due to the attraction of the Moon, and that the height of the tides depends on the Moon's position relative to the Sun.[161] Alternatively, he may have proved heliocentricity by determining the constants of a geometric model for it, and by developing methods to compute planetary positions using this model, like what Nicolaus Copernicus later did in the 16th century.[162] During the Middle Ages, heliocentric models were also proposed by the Indian astronomer Aryabhata,[163] and by the Persian astronomer Aryabhata,[163] and by the Persian astronomer Aryabhata,[164] and Al-Sijzi.[165] Model of the Copernican Universe by Thomas Digges in 1576, with the amendment that the stars are no longer confined to a sphere, but spread uniformly throughout the space surrounding the planets. After nucleosynthesis ended, the universe entered a period known as the photon epoch. (1977). Analyses of Type Ia supernovae indicate that the spatial expansion is accelerating.[62][63] The more matter there is in the universe, the stronger the mutual gravitational pull of the matter. ^ Blandford R. This reflects the 2008 limits of WMAP's ability to define dark matter and dark energy. B. (1914). Retrieved July 27, 2015. doi:10.1111/j.1745-3933.2011.01040.x. S2CID 2616287. { cite journal }: CS1 maint: uses authors parameter (link) ^ Schreiber, Urs (June 6, 2008). 1917. ISBN 978-0-08-018176-9. Oxford: O billion years, the universe had expanded sufficiently so that the density of matter was less than the density of dark energy, marking the beginning of the universe is accelerating due to dark energy. Myth and Knowing: An Introduction to World Mythology (1st ed.). As a 3-sphere moves through a given three-dimensional hyperplane, the intersection starts out as a point, then becomes a growing 2-sphere that reaches its maximal size when the hyperplane cuts right through the "equator" of the 3-sphere The four Euclidean coordinates for S3 are redundant since they are subject to the condition that x02 + x12 + x22 + x32 = 1. Therefore, solutions of the Einstein field equations describe the evolution of the universe. Bibcode:2001LRR.....4...1C. The European Space Agency (ESA). ^ NASA/WMAP Science Team (January 24, 2014). It follows that the tangent bundle of the 3-sphere is trivial. An overall dimensionless length scale factor R describes the size scale of the universe. [128] A curvature index k describes the geometry. We first describes the size scale of the universe as a function of time; an increase in R is the expansion of the universe. [128] A curvature index k describes the geometry. We first describe the lower-dimensional version. 38 (2): 101-50. "Dark Energy". 'almost perfect' universe". ^ Schutz, Bernard (May 31, 2009). In other stories, the universe emanates from fundamental principles, such as Brahman and Prakrti, the creation myth
of the Serers, [150] or the yin and yang of the Tao. arXiv:hep-th/0610199. Any unit quaternion q can be written as a versor: q = e τ ψ = cos ψ + τ sin ψ {\displaystyle} q=e^{\tau \psi }=\cos \psi +\tau \sin \psi } where τ is a unit imaginary quaternion; that is, a quaternion that satisfies τ2 = -1. In E. ^ "Thermal history of the universe and early growth of density fluctuations" (PDF). Democritus, and later philosophers—most notably Leucippus—proposed that the universe is composed of indivisible atoms moving through a void (vacuum), although Aristotle did not believe that to be feasible because air, like water, offers resistance to motion. Some boron may have been formed at this time, but the next heavier element, carbon, was not formed in significant amounts. pp. 569, 909, 1900, 3821-22. The basic elements of spacetimes are events. "A test of the Poincare dodecahedral space topology hypothesis with the WMAP CMB data". Retrieved December 31, 2011. Traité de la Comète. John Wiley & Sons. The earliest cosmological models of the universe were developed by ancient Greek and Indian philosophers and were geocentric, placing Earth at the center.[12][13] Over the centuries, more precise astronomical observations led Nicolaus Copernicus to develop the heliocentric model with the Sun at the center of the Solar System. ISBN 978-1-00-901369-7. However, the Penrose-Hawking singularity theorems show that a singularity should exist for very general conditions. ISBN 978-0-04-291001-7. Other contents are electromagnetic radiation (estimated to constitute from 0.005% to close to 0.01% of the universe) and antimatter.[80][81][82] The proportions of all types of matter and energy have changed over the history of the universe.[83] The total amount of electromagnetic radiation generated within the universe has decreased by 1/2 in the past 2 billion years [84][85] Today, ordinary matter, which includes atoms, stars, galaxies, and life, accounts for only 4.5 × 10-31 grams per cubic centimetre, corresponding to a density of the order of only one proton for every four cubic metres of volume.[6] The nature of both dark energy and dark matter is unknown. "Eternal chaotic inflation". doi:10.1038/scientificamerican0811-38. Bibcode:2003SciAm.288e..40T. "Hypersphere". At around 47,000 years, the energy density of matter became larger than that of photons and neutrinos, and began to dominate the large scale behavior of the universe Bibcode: 2003RvMP...75..559P. Moreover, since quaternionic multiplication is smooth, S3 can be regarded as a real Lie group. ^ Hall, Shannon (May 4, 2015). Science in the Quran. ^ Larson, Richard B. Particle Physics and Astronomy Research Council. Because this projection is conformal, the curves intersect each other orthogonally (in the yellow points) as in 4D. Liddell, H. "The Flat Torus in the Three-Sphere". This implies that the 3-sphere is parallelizable. arXiv:astro-ph/9805201. A spacetime is the union of all of its points), formally organized into a manifold.[66] Events, such as matter and energy, bend spacetime. {\displaystyle \sum  $\{i=0\}^{3}(x \{i\}-C \{i\})^{2}=(x \{0\}-C \{0\})^{2}=(x \{0\}-C \{0\})^{2}=($ formula. D. 1st edition by Harvard University Press, 2nd edition by State University of New York Press. A. "Planck 2015 results. quaternions and spatial rotations), it describes a rotation about  $\tau$  through an angle of 2 $\psi$ . The index k is defined so that it can take only one of three values: 0, corresponding to flat Euclidean geometry; 1, corresponding to a space of positive curvature; or -1, corresponding to a space of positive or negative curvature.[129] The value of R as a function of time t depends upon k and the cosmological constant represents the energy density of the vacuum of space and could be related to dark energy.[87] The equation describing how R varies with time is known as the Friedmann equation after its inventor, Alexander Friedmann.[130] The solutions for R(t) depend on k and A, but some qualitative features of such solutions are general. "RIP Universe - Your Time Is Coming... Slowly | Video". Bibcode: 2008FoPh...38..101T. "Dodecahedral space topology as an explanation for weak wide-angle temperature correlations in the cosmic microwave background". 258 (1): 14P-18P. Landau L, Lifshitz E (1975). 2015. As to the homotopy groups, we have  $\pi_1(S_3) = \{\}$  and  $\pi_3(S_3)$  is infinite cyclic. In search of the ultimate building blocks. ^ a b Schreuder, Duco A. & Ratra, Bharat (2003). This is known as recombination for historical reasons. in fact electrons and nuclei were combining for the first time. S2CID 162347339. "Kosmologische Betrachtungen zur allgemeinen Relativitätstheorie". Bibcode: 2006GReGr..38..643B. Since S3 is not homeomorphic to S2 × S1, the Hopf bundle is nontrivial. The universe is bathed in highly isotropic microwave radiation that corresponds to a thermal equilibrium blackbody spectrum of roughly 2.72548 kelvins.[7] The hypothesis that the large-scale universe is homogeneous and isotropic looks the same from all vantage points[101] and has no center.[102] Dark energy Main article: Dark energy An explanation for why the expansion of the universe is accelerating remains elusive. (2010). Why Does the World Exist?. Kirchner; W.R. Stoeger (2004). Introductory Astronomy & Astrophysics (4th ed.). ^ a b Fixsen, D.J. (2009). Henderson, Experiencing Geometry: In Euclidean, Spherical, and Hyperbolic Spaces, second edition, 2001, [1] (Chapter 20: 3-submanifold of R4. doi:10.1086/370729. Both systems, therefore, agree in denying the objective reality of the categories of Substance and Quality,... Ars technica. pp. 1-3. During this period, the universe was still far too hot for matter to form neutral neutrinos. and positive nuclei. Likewise, we may inflate the 2-sphere, moving the pair of disks to become the northern and southern hemispheres. arXiv:astro-ph/9812133. ^ Aristotle; Forster, E. S2CID 125190902. NASA. The ultimate fate of the universe is still unknown because it depends critically on the curvature index k and the cosmological constant A. Liveright Publishing. "Measurements of Omega and Lambda from 42 high redshift supernovae". 116 (3): 1009-38. Then the 2-sphere shrinks again down to a single point as the 3-sphere leaves the hyperplane. "Observational evidence from supernovae for an accelerating universe and a cosmological constant". "Beyond charm". "Synthetic construction of the Hopf fibration in a double orthogonal projection of 4-space". ISBN 978-0-262-54003-2. ^ The Compact Edition of the Oxford English Dictionary. Oxford: The Clarendon Press. Retrieved March 17, 2011. Saunders College Publishing. Archived from the original on May 27, 2013. ^ Copan, Paul; William Lane Craig (2004). S2CID 205260736. Astrophysical Journal. (June 2016) (Learn how and when to remove this template message) Stereographic projection of the hypersphere's parallels (red), meridians (green). Cambridge University Press. arXiv:astro-ph/9901364. Note that, for any fixed value of ψ, θ and φ parameterize a 2-sphere of radius r sin ψ, except for the degenerate cases, when  $\psi$  equals 0 or  $\pi$ , in which case they describe a point. Astrophysics and Space Science.  $\delta \left(2015\right)$ . {\displaystyle {\begin{aligned}} + e\_{x\_{1}} + e\_{x\_{1 to π/2, and ξ1 and ξ2 can take any values between 0 and 2π. A Brief History of Time. It turns out that the only spheres that admit a Lie group structure are S1, thought of as the set of unit complex numbers, and S3, the set of unit a Lie group structure are S1, thought of as the set of unit complex numbers and S3, the set of unit complex numbers, and S3, the set of unit a Lie group structure are S1, thought of as the set of unit a Lie group structure are S1, thought of as the set of unit a Lie group structure are S1, thought of as the set of unit a Lie group structure are S1, thought of as the set of unit a Lie group structure are S1, thought of as the set of unit a Lie group structure are S1, thought of a structure are S1, thought o dimensional one). Bibcode:1979AmJPh..47.1031P. North-Holland. In complex coordinates (z1, z2)  $\in$  C2 we write z 1 = e i  $\xi$  2 cos  $\eta$ . Elsevier. Phys. JSTOR 90845. Arrari, H. "Universe 101: What is the Universe 101: What is t S2CID 52996408. {{cite journal}}: CS1 maint: uses authors parameter (link) ^ Ellis G. Second, all solutions suggest that there was a gravitational singularity in the past, when R went to zero and matter and energy were infinitely dense. A true force-particle "theory of everything" has not been attained.[118] Hadrons Main article: Hadron A hadron is a composite particle made of quarks held together by the strong force. (1979). In the same way, removing a single point from the 3-sphere yields three-dimensional space. "Chaldaean Astronomy of the Last Three Centuries B. This terminology is standard among mathematicians, but not among physicists. "Could Feynman Have Said This?". "Susskind's Challenge to the Hartle-Hawking No-Boundary Proposal and Possible Resolutions". For a general discussion of the number of linear independent vector fields on a n-sphere, see the article vector fields on spheres. 635 (1): L37-L40. University of Texas at Austin. p. 613. Page (2007). Max Planck Institute for Astrophysics. From approximately 10–6 seconds after the Big Bang, during a period is known as the hadron epoch, the temperature of the universe had fallen sufficiently to allow quarks to bind together into hadrons. Retrieved January 3, 2007. OCLC 893872366. S2CID 1616362. 57 (5): 10. In a given three-dimensional hyperplane, a 3-sphere can rotate about an "equatorial plane" (analogous to a 2-sphere rotating about a central axis), in which case it appears to be a 2-sphere whose size is constant. PMID 12701329. "Planck 2013 results. p. 400. (2012). Composition See also: Galaxy formation and evolution, Galaxy cluster, Illustris project, and Nebula The universe is composed almost
completely of dark energy, dark matter, and ordinary matter. ^ Gernet, J. ^ Carroll, Sean; Kaku, Michio (2014). "The baryon content of the Universe". Bibcode:2004CQGra..21.4901A. Archived from the original on March 7, 2004. 425 (6958): 593-95. March 21, 2013. Thales' student, Anaximander, proposed that everything came from the limitless apeiron. Consequently, the sum of the charges on the two sides of the surface is zero." ^ Kaku, Michio (March 11, 2008). This defines an atlas on S3 consisting of two coordinate charts or "patches", which together cover all of S3. The only other spheres with such a structure are the 0-sphere and the 1-sphere (see circle group). p. 218. Quarks, Leptons and the Big Bang (Second ed.). Springer. General relativity generalizes special relativity and Newton's law of universal gravitation, providing a unified description of gravity as a geometric property of space and time, or spacetime. A map of the superclusters and voids nearest to Earth Matter, and dark energy are distributed homogeneously throughout the universe over length scales longer than 300 million light-years or so.[88] However, over shorter length-scales, matter tends to clump hierarchically; many atoms are condensed into stars, most galaxies, matter tends to clump hierarchically; many atoms are condensed into stars, most galaxies, matter tends to clump hierarchically; many atoms are condensed into stars, most stars into galaxies, most galaxies, matter tends to clump hierarchically; many atoms are condensed into stars, most galaxies, matter tends to clump hierarchically; many atoms are condensed into stars, most galaxies, matter tends to clump hierarchically; many atoms are condensed into stars, most galaxies, matter tends to clump hierarchically; many atoms are condensed into stars, most galaxies, matter tends to clump hierarchically; many atoms are condensed into stars, most galaxies, matter tends to clump hierarchically; many atoms are condensed into stars, most galaxies, most galaxi Francis. Bibliography Bartel, Leendert van der Waerden (1987). arXiv:1807.06209. Conversely, if the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever, cooling off and eventually reaching the Big Freeze and the heat death of the universe would expand forever. universe is not decreasing, as originally expected, but increasing; if this continues indefinitely, the universe may eventually reach a Big Rip. ^ Roukema, Boudewijn; Buliński, Zbigniew; Szaniewska, Agnieszka; Gaudin, Nicolas E. ^ Veltman, Martinus (2003). Size and regions See also: Observational cosmology Television signals broadcast from Earth will never reach the edges of this image. Archived from the original on 23 February 2013. 12 (2): 231-55. The highly redshifted photons from the chaotic inflation model of the early universe resulting from the cosmic microwave background. An example of such multiverses is the one resulting from the chaotic inflation model of the early universe. many-worlds interpretation of quantum mechanics. Oxford University Press. For any fixed value of η between 0 and π/2, the coordinates (ξ1, ξ2) parameterize a 2-dimensional torus. ^ Palmer, Jason. Bibcode:2011MNRAS.413L..91V. doi:10.1007/s10714-006-0254-9. ISBN 978-0-87395-907-0. MathWorld. Raine, D. Spacetime events are not absolutely defined spatially and temporally but rather are known to be relative to the motion of an observer. 29 (3): 454-62. Perhaps unsurprisingly, our universe has just the right mass-energy density, equivalent to about 5 protons per cubic metre, which has allowed it to expand for the last 13.8 billion years, giving time to form the universe as observed today [64] There are dynamical forces acting on the particles in the universe which affect the expansion rate. Since the Planck epoch, space has been expanding to its present scale, with a very short but intense period of cosmic inflation believed to have occurred within the first 10–32 seconds.[41] This was a kind of expansion different from those we can see around us today. For example, a Dehn filling with slope 1/n on any knot in the 3-sphere gives a homology sphere; typically these are not homeomorphic to the 3-sphere. Hence, according to Einstein's field equations, R grew rapidly from an unimaginably hot, dense state that existed immediately following this singularity (when R had a small, finite value); this is the essence of the Big Bang model of the universe. It is the force carrier for the electromagnetic force, even when static via virtual photons. Before 1998, it was expected that the expansion rate would be decreasing as time went on due to the influence of gravitational interactions in the universe; and thus there is an additional observable quantity in the universe called the deceleration parameter, which most cosmologists expected to be positive and related to the matter density of the universe. ^ a b Planck 2015 results, table 9 ^ Persic, Massimo; Salucci, Paolo (September 1, 1992). Note: This article uses the alternate naming scheme for spheres in which a sphere in not sphere in the universe. dimensional space is termed an n-sphere. Retrieved March 31, 2012. ^ Singh, Simon (2005). ^ Edward Robert Harrison (2000). In the earliest stages of the universe, tiny fluctuations within the universe's density led to concentrations of dark matter gradually forming. The Big Bang model accounts for observations such as the correlation of distance and redshift of galaxies, the ratio of the number of hydrogen to helium atoms, and the microwave radiation background. { $displaystyle S^{3}=left_{x {0}, x {3}}$  is often convenient to regard R4 as the space with 2 complex dimensions (C2) or the quaternions (H). Bibcode: 2000eso..pres...12. p. 308. This construction is analogous to a construction of a 2-sphere, performed by gluing the boundaries of a pair of disks. {\displaystyle H={\frac {1}{2}}\pi ^{2}r^{4}.} Every non-empty intersection of a 3-sphere with a three-dimensional hyperplane is a 2-sphere (unless the hyperplane is tangent to the 3-sphere, in which case the intersection is a single point). {\displaystyle  $S^{1}\to S^{2}$ .} A diagram depicting the poloidal ( $\xi_1$ ) direction, represented by the blue arrow, although the terms poloidal and toroidal are arbitrary in this flat torus case. The Accelerating Universe: the metric governing spacetime itself. 1971. Any other element was only formed in very tiny quantities. Anaximenes proposed the primordial material to be air on account of its perceived attractive and repulsive qualities that cause the arche to condense or dissociate into different forms. ^ Bars, Itzhak; Terning, John (November 2009). ^ Carroll, Sean (2001). Dictionary.com. At smaller scales, galaxies are distributed in clusters and superclusters which form immense filaments and voids in space, creating a vast foam-like structure.[14] Discoveries in the early 20th century have suggested that the universe had a beginning and that space has been expanding since then[15] at an increasing rate.[16] According to the Big Bang theory, the energy and matter initially present have become less dense as the universe expanded. 755-56. San Francisco: W. 707 (2): 916-20. From studying the movement of galaxies, it has been discovered that the universe contains much more matter than is accounted for by visible objects; stars, galaxies, nebulas and interstellar gas. However, as the temperature of the universe continued to fall, hadron/anti-hadron pairs, which kept matter and antimatter in thermal equilibrium. arXiv:astro-ph/0511045. Big Bang: The Origin of the Universe. Just as on the 2-sphere, one must use at least two coordinate charts. Retrieved July 26, 2015. Together, these epochs encompassed less than 10 seconds of time following the Big Bang. "The History of Ancient Astronomy Problems and Methods". In related stories, the universe is created by a single entity emanating or producing something by him- or herself, as in the Tibetan Buddhism concept of Adi-Buddha, the ancient Greek story of Gaia (Mother Earth), the Aztec goddess Coatlicue myth, the Aztec goddess Coatlicue myth, the ancient Egyptian god Atum story, and the Judeo-Christian Genesis creation narrative in which the Abrahamic God created the universe. doi:10.1063/1.1768652. The orbit space of this action is homeomorphic to the two-sphere S2. Gluing A 3-sphere can be constructed topologically by "gluing" together the boundaries of a pair of 3-balls. David W. External links Universeat Wikipedia's sister projectsDefinitions from Wikipedia's from Wikipedia's sister projectsDefinitions from Wikipedia's sister projectsDef WikibooksResources from Wikiversity Listen to this article(4 parts, 1 hour and 13 minutes) These
audio files were created from a revision of this articles) NASA/IPAC Extragalactic Database (NED) / (NED-Distances). ^ a b Braibant, Sylvie; Giacomelli, Giorgio; Spurio, Maurizio (2012). The inverse of this map takes p = (x0, x1, x2, x3) in S3 to u = 1.1 + x.0 (x.1, x3, x3) in S3 to u = 1.1 + x.0 (x.1, x3, x3) in S3 to u = 1.1 + x.0 (x.1, x3, x3) in S3 to u = 1.1 + x.0 (x.1, x3, x3) in S3 to u = 1.1 + x.0 (x.1, x3, x3) in S3 to u = 1.1 +Population III stars. Anaxagoras proposed the principle of Nous (Mind), while Heraclitus proposed fire (and spoke of logos). This horizon represents the boundary between the observable regions of the universe.[71][72] The existence, properties, and significance of a cosmological horizon depend on the particular cosmological model. ^ Will the Universe expand forever?, WMAP website at NASA. Roughly a century before Copernicus, the Christian scholar Nicholas of Cusa also proposed that the Earth rotates on its axis. A toroidal universe could behave like a normal universe with periodic boundary conditions. An extremely useful way to see this is via stereographic projection. First and most importantly, the length scale R of the universe can remain constant only if the universe is perfectly isotropic with positive curvature (k=1) and has one precise value of density everywhere, as first noted by Albert Einstein. [127] However, this equilibrium is unstable: because the universe is inhomogeneous on smaller scales, R must change over time. "How Many Galaxies Are There?". For more discussion see homotopy groups of spheres. (December 3, 2014). ISSN 0004-6361. ^ Planck Collaboration (2014). ^ "First few minutes". pp. 202-. May 3, 2000. ^ a b c d e f g Ellis, George F.R.; U. As with all spheres, the 3-sphere has constant positive sectional curvature equal to 1/r2 where r is the radius. 482 (3): 747-53. May 4, 2009. The stars are in fact much farther away than the distance that was generally assumed in ancient times, which is why stellar parallax is only detectable with precision instruments. Objects in space did not physically move; instead the metric that defines space itself changed. Bibcode:1902RSPTA.199....1J. 754. Empirical evidence for the Earth's rotation on its axis, using the phenomenon of comets, was given by Tusi (1201-1274) and Ali Qushji (1403-1474).[168] This cosmology was accepted by Isaac Newton, Christiaan Huygens and later scientists.[169] Edmund Halley (1720)[170] and Jean-Philippe de Chéseaux (1744)[171] noted independently that the assumption of an infinite space filled uniformly with stars would be as bright as the Sun itself; this became known as Olbers' paradox in the 19th century.[172] Newton believed that an infinite space uniformly filled with matter would cause infinite forces and instability criterion.[173] One solution to these paradoxes is the Charlier Universe, in which the matter is arranged hierarchically (systems of orbiting bodies that are themselves orbiting in a larger system, ad infinitum) in a fractal way such that the universe has a negligibly small overall density; such a cosmological model had also been proposed earlier in 1761 by Johann Heinrich Lambert. [52][174] A significant astronomical advance of the 18th century was the realization by Thomas Wright, Immanuel Kant and others of nebulae.[170] In 1919, when the Hooker Telescope was completed, the prevailing view still was that the universe consisted entirely of the Milky Way Galaxy. 144-45, ISBN 3-515-02842-0 ^ B. 6.33 ^ "Antimatter". (1902). The Unfinished Universe. Franz Steiner Verlag. S2CID 119335614. This matrix subgroup is precisely the special unitary group SU(2). Unlike the 2-sphere, the 3-sphere admits nonvanishing vector fields (sections of its tangent bundle). arXiv:astro-ph/0605173. Retrieved March 5, 2021. Extra Dimensions in Space and Time. 1933, 1977-1978. "Higgs boson FAQ". It suggests that about 69.2%±1.2% [2015] of the mass and energy in the universe is a cosmological constant (or, in extensions to ACDM, other forms of dark energy, such as a scalar field) which is responsible for the current expansion of space, and about 25.8% ± 1.1% [2015] is dark matter.[18] Ordinary ('baryonic') matter is therefore only 4.84% ± 0.1% [2015] of the physical universe.[18] Stars, planets, and visible gas clouds only form about 6% of the ordinary matter [19] There are many competing hypotheses about the ultimate fate of the universe and about what, if anything, preceded the Big Bang, while other physicists and philosophers refuse to speculate, doubting that information about prior states will ever be accessible. ^ Sharov, Aleksandr Sergeevich, Novikov, Igor Dmitrievich (1993). ^ Mackie, Glen (February 1, 2002). Index to Creationist Claims. His four-element model became very popular. EarthSky. Astronomical Journal. (1998). The Indian philosopher Kanada, founder of the same substance.[152] In the 5th century AD, the Buddhist atomist philosopher Dignāga proposed atoms to be point-sized, durationless, and made of energy. arXiv:astro-ph/0310253. The universe appears to have much more matter than antimatter is partially responsible for the existence of all matter existing today, since matter and antimatter, if equally produced at the Big Bang, would have completely annihilated each other and left only photons as a result of their interaction.[45][46] The universe also appears to have neither net momentum nor angular momentum, which follows accepted physical laws if the universe is finite. doi:10.1051/0004-6361:20078777. 64 (4). (1968). Peterson describes three different ways of visualizing 3-spheres and points out language in The Divine Comedy that suggests Dante viewed the Universe in the same way; Carlo Rovelli supports the same idea.[5] In Art Meets Mathematics in the Fourth Dimension [6] Stephen L. Journal of the History of Ideas. F (2011). ^ "Dark matter - A history shapes by dark force". Lipscomb develops the concept of the hypersphere dimensions as it relates to art, architecture, and mathematics. The electron governs nearly all of chemistry, as it is found in atoms and is directly tied to all chemical properties. Combined with measurements of the amount, type, and distribution of the universe is homogeneous and isotropic everywhere, a specific solution of the universe is the universe over time. [127] With the assumption of the universe is the universe over time. [127] With the assumption of the universe is t metric tensor called the Friedmann-Lemaître-Robertson-Walker metric, d s 2 =  $-c 2 d t 2 + r 2 d \theta 2 + r 2 sin 2 \theta d \phi 2$  {\lisplaystyle ds^{2}+r^{2}\linkr^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}+r^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta
2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r 2 sin 2 \theta d \phi 2 } {\lisplaystyle ds^{2}} + r^{2} d \theta 2 + r^{2} d system. Air will immediately rush in to fill a void, and moreover, without resistance, it would do so indefinitely fast.[13] Although Heraclitus argued for eternal change is an illusion, that the true underlying reality is eternally unchanging and of a single nature. ^ Luminet, Jean Pierre; Roukema, Boudewijn F. Hyperspherical coordinates It is convenient to have some sort of hyperspherical coordinates on S3 in analogy to the usual spherical coordinates on S3 in analogy to the usual spherical coordinates on S3 in analogy to the usual spherical coordinates on S2. pp. 703-816. Steiner (1997), pp. The New Physics: A Synthesis. doi:10.1051/0004-6361/201321591. The Goldilocks Enigma. The Jains more nearly approximated to Democritus by teaching that all atoms were of the same kind, producing different effects by diverse modes of combinations. Infinitely many homology spheres are now known to exist. Vardanyan, R. ^ a b Planck Collaboration (2016). Unlike plasma, neutral atoms are transparent to many wavelengths of light, so for the first time the universe also became transparent. Movement consists for them of moments, it is a staccato movement, momentary flashes of a stream of energy... S2CID 17619026. ^ M. Bibcode: 2008A&A...482..747L. "The Higgs FAQ 2.0". Cosmologists often work with a given space-like slice of spacetime called the comoving coordinates. Vol. 29. Davies (1992). Minkowski space-like slice of spacetime called the comoving coordinates. Vol. 29. Davies (1992). approximates the universe without gravity; the pseudo-Riemannian manifolds of general relativity describe spacetime with matter and gravity; the pseudo-Riemannian manifolds of general relativity describe spacetime with matter and gravity. Journal of the American Oriental Society. The exponential map for 3-sphere is similarly constructed; it may also be discussed using the fact that the 3-sphere is the Lie group of unit quaternions. The Whole Shebang: A State-of-the-Universe(s) Report. Routledge. "How Many Stars Are There In The Universe?". ISBN 978-0-618-59226-5. "The Temperature of the Cosmic Microwave Background". ^ "Universe". ^ Steinhardt, Paul J.; Turok, Neil (2006). New York: Springer Verlag. The homology groups of the 3-sphere are as follows: H0(S3, Z) and H3(S3, Z) are both infinite cyclic, while Hi(S3, Z) = {} for all other indices i. "About the Infinite Repetition of Histories in Space". 21 (21): 4901-26. ^ "What is the Ultimate Fate of the Universe?". "First Determination of the Distance and Fundamental Properties of an Eclipsing Binary in the Andromeda Galaxy". doi:10.2307/595168. Michael Banks. ^ Adamson, Allan (October 19, 2017). arXiv:astro-ph/0302131. ^ Raine & Thomas (2001, p. 12) ^ a b Raine & Thomas (2001, p. 66) ^ Friedmann A. An Introduction to Modern Astrophysics (International ed.). The first to do so was Thales, who proposed this material to be water. The geocentric model, consistent with planetary parallax, was assumed to be an explanation for the unobservability of the parallel phenomenon, stellar parallax. arXiv:gr-qc/0407022. ^ Boyer, C. Tiny variations in temperature and density detectable in the CMB were the early "seeds" from which all subsequent structure formation took place.[119]:244-66 Cosmological models Model of the universe based on general relativity Main article: Solutions of the Einstein field equations See also: Big Bang and Ultimate fate of the universe General relativity is the geometric theory of gravitation in modern physics. ^ Moskowitz, Clara (August 12, 2011). ^ Fritzsche, Hellmut. The 3-sphere is homeomorphic to the one-point compactification of R3. ^ "WolframAlpha". Direct projection of 3-sphere is a higher-dimensional analogue of a sphere. The same synonyms are found in English, such as everything (as in the theory of everything) in mathematics, a 3-sphere is a higher-dimensional analogue of a sphere.  $0 - Dark Ages Reionization Matter-dominated eraAccelerated expansion Water on Earth Single-celled lifePhotosynthesis MulticellularlifeVertebrates <math>\leftarrow$  Earliest galaxy  $\leftarrow$  Milky Way spirals  $\leftarrow$  NGC 188 star cluster  $\leftarrow$  Alpha Centauri  $\leftarrow$  Earliest galaxy  $\leftarrow$  Cuasar / black hole  $\leftarrow$  Omega Centauri  $\leftarrow$  Earliest galaxy  $\leftarrow$  Milky Way spirals  $\leftarrow$  Earliest galaxy  $\leftarrow$  Milky Way spirals  $\leftarrow$  Milky Way spirals  $\leftarrow$  Earliest galaxy  $\leftarrow$  Milky Way spirals  $\leftarrow$  Earliest galaxy  $\leftarrow$  Milky Way spirals  $\leftarrow$  Milky Milky Way spirals  $\leftarrow$  Milky May known life-Earliest oxygen-Sexual reproduction-Earliest animals / plants-Cambrian explosion-Earliest animals / plants-Cambrian explosion-Earliest animals / plants-Cambrian explosion-Earliest state of the universe is the Big Bang model states that the earliest state of the universe is the Big Bang model states that the earliest state of the universe is the Big Bang model for the evolution of the universe is the Big Bang model for t was an extremely hot and dense one, and that the universe subsequently expanded and cooled. The proper distance—the distance as would be measured at a specific time, including the present—between Earth and the edge of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[50] making the diameter of the observable universe is 46 billion light-years[49] (14 billion parsecs),[5 about 93 billion light-years (28 billion parsecs).[49] The distance the light from the edge of the observable universe and the Earth have since moved further apart.[51] For comparison, the diameter of a typical galaxy is 30,000 light-years (919.8 kiloparsecs).[52] As an example, the Milky Way is roughly 100,000-180,000 light-years in diameter,[53][54] and the nearest sister galaxy to the Milky Way, the Andromeda Galaxy, is located roughly 2.5 million light-years away.[55] Because we cannot observe space beyond the edge of the universe, it is unknown whether the size of the universe in its totality is finite.[3][56][57] Estimates suggest that the whole universe, if finite, must be more than 250 times larger than the observable universe.[58] Some disputed[59] estimates for the total size of the universe, if finite, reach as high as 10 10 122 {\displaystyle 10^{10^{122}}} megaparsecs, as implied by a suggested resolution of the No-Boundary Proposal.[60][b] Age and expansion Main articles: Age of the universe and Metric expansion of space Astronomers
calculate the age of the universe by assuming that the Lambda-CDM model accurately describes the evolution of the Universe from a very uniform, hot, dense primordial state to its present state and measuring the cosmological parameters which constitute the model.[citation needed] This model is well understood theoretically and supported by recent high-precision astronomical observations such as WMAP and Planck.[citation needed] Commonly, the set of observations fitted includes the cosmic microwave background anisotropy, the brightness/redshift relation for Type Ia supernovae, and large-scale galaxy clustering including the baryon acoustic oscillation feature.[citation needed] Other observations, such as the Hubble constant, the abundance of galaxy clusters, weak gravitational lensing and globular cluster ages, are generally consistent with these, providing a check of the model, but are less accurately measurements of the model. parameters using a variety of techniques by numerous experiments yield a best value of the age of the universe as of 2015 of 13.799 ± 0.021 billion years old. This selects one of three possible geometries depending on whether Ω is equal to, less than, or greater than 1. (1945). {\displaystyle \mathbf {v} = {\frac {1}{1-x {0}}} left(x {1}, x {2}, x {3}\right).} Note that the u coordinates everywhere but (1, 0, 0, 0). Most of the hadrons and anti-hadrons were then eliminated in particle-antiparticle annihilation reactions, leaving a small residual of hadrons by the time the universe was about one second old.[119]: 244-66 Leptons Main article: Lepton A lepton is an elementary, half-integer spin particle that does not undergo strong interactions but is subject to the Pauli exclusion principle; no two leptons of the same species can be in exactly the same state at the same time.[120] Two main classes of leptons exist: charged leptons (also known as the electron-like leptons), and neutral leptons (better known as neutrinos). Art meets mathematical object This article includes a list of general references, but it lacks sufficient corresponding inline citations. "Relative State Formulation of Quantum Mechanics". So don't be surprised if you find people calling the two-sphere a three-sphere.) Zamboj, Michal (8 Jan 2021). For example, if we project from the point (-1, 0, 0, 0) we can write a point p in S3 as  $p = (1 - \| u \| 2 1 + \| u \| 2 1 +$  $p=\left(\left(\frac{1+|u|^{2}}{1+|u|^{2}}\right)\right)$  where  $u = (u_1, u_2, u_3)$  is a vector in R3 and  $||u||^2 = u_1^2 + u_2^2 + u_3^2$ . Bibcode:1986Ap&SS.125..1895. "Dante and the 3-sphere". "Topology of the Universe: Theory and Observations". Journal of Near Eastern Studies. This metric has only two undetermined parameters. ISBN 978-0-385-52544-2. doi:10.1086/499161. Other Greek scientists, such as the Pythagorean philosopher Philolaus, postulated (according to Stobaeus account) that at the center of the universe was a "central fire" around which the Earth, Sun, Moon and planets revolved in uniform circular motion.[156] The Greek astronomer Aristarchus of Samos was the first known individual to propose a heliocentric model of the universe. 1997. ISSN 0035-8711. 1 (2): 81-85. (1993-1994). 312 (5777): 1180-83. A Bartel (1987, p. Dreams of a Final Theory: The Scientist's Search for the Ultimate Laws of Nature. CiteSeerX 10.1.1.338.7953 doi:10.1007/s10701-007-9186-9. "One Universe or Many?". p. 21. ISBN 978-0-8010-2733-8. arXiv:2003.09236v2. After about 377,000 years, the universe had cooled enough that electrons and nuclei could form the first stable atoms. ^ a b Zeilik, Michael; Gregory, Stephen A. Knopf Doubleday Publishing Group. pp. 135–36. They were responsible for the gradual reionization of the universe between about 200-500 million years, and also for seeding the universe with elements heavier than helium, through stellar nucleosynthesis.[42] The universe also contains a mysterious energy—possibly a scalar field—called dark energy, the density of which does not change over time. Vol. 1 "A Greek-English Lexicon". They are called "qualities" (guna-dharma) in both systems in the sense of absolute qualities, a kind of atomic, or intra-atomic, energies of which the empirical things are composed. 450 BC), Heraclides Ponticus (c. Retrieved September 29, 2010. What we call quality is but a particular manifestation of a subtle entity. These elementary particles associated stably into ever larger combinations, including stable protons and neutrons, which then formed more complex atomic nuclei through nuclear fusion. ISBN 978-0-19-280434-1. Physics from symmetry. One might think that S7, the set of unit octonions, would form a Lie group, but this fails since octonion multiplication is fails since octonion multiplication is faily since octonion. nonassociative. Les Houches Summer School Proceedings. When thought of as a Lie group S3 is often denoted Sp(1) or U(1, H). "It's Official: The Universe Is Dying Slowly". The section of spacetime which can be observed is the backward light cone, which delimits the cosmological horizon. "End of the Universe". ^ Redd, SPACE.com, Nola Taylor. Encyclopaedia Britannica Inc. doi:10.1093/mnras/258.1.14P. Cosmology: the science of the universe, ^ a b Sean Carroll, Ph.D., Caltech, 2007, The Teaching Company, Dark Matter, Dark Energy: The Dark Side of the Universe, ^ a b Sean Carroll, Ph.D., Caltech, 2007, The Teaching Company, Dark Matter, Dark Energy: The Dark Side of the Universe, Guidebook Part 2 p. F. PMID 16675662. Stereographic projection of a 3-sphere (again removing the north pole) maps to three-space in the same manner. PMID 14534579. ^ "Timeline of the Big Bang". Because the set of unit quaternions is closed under multiplication, S3 takes on the structure of a group. How the Universe Works. Since the open unit disk is homeomorphic to the Euclidean plane, this is again a one-point compactification. S2CID 17178479. ISBN 978-0-13-236678-6. If the universe were too dense then it would re-collapse into a gravitational singularity. Mass, charge, and spin are listed for each particle. Th. (1930, 1962), Buddhist Logic, Volume 1, p. Philip Gibbs. An Introduction to the Science of Cosmology. doi:10.1111/j.1365-2966.2004.07261.x. S2CID 119028830. "Many Worlds in One". After an initial accelerated expansion called the inflationary epoch at around 10-32 seconds, and the separation of the four known fundamental forces, the universe gradually cooled and continued to expand, allowing the first subatomic particles and simple atoms to form. Rest the south pole of a unit 2-sphere on the xy-plane in three-space. pp. 65-68. pp. 193-244. arXiv:astro-ph/0305292. ^ a b "The Nobel Prize in Physics 2011". 347 (6226): 1103-08. If the Big Bang that created our multiverse created an ensemble of multiverse, the wave function of the ensemble would be entangled in this sense.[138] The least controversial, but still highly disputed, category of multiverse in Tegmark's scheme is Level I. John Wiley and Sons. The images, labeled along their left edge, increase in size from left to right, then from top to bottom. Superpose them and glue corresponding points on their boundaries. Bibcode:1992MNRAS.258P..14P. Guinevere Kauffmann. Retrieved April 15, 2013. Namely, every closed surface in a finite space encloses on each side of itself a finite region of space. A disk is a 2-ball, and the boundary of a disk is a circle (a 1-sphere). "Evolution of the Universe through the Planck epoch". "What is Dark Matter?". Dark matter, a mysterious form of matter that has not yet been identified, accounts for 26.8% of the cosmic contents. S2CID 15640044. J.; Thomas, E. The observable 7. ^ Ragep, F. doi:10.1088/1475-7516/2007/01/004. These laws are Gauss's law and the non-divergence of the stress-energy-momentum pseudotensor.[47] Constituent spatial scales of the observable universe This diagram shows Earth's location in the universe on increasingly larger scales. S2CID 119000743.{{cite journal}}: CS1 maint: uses authors parameter (link) ^ a b Tegmark M. Using our Hopf coordinates (η, ξ1, ξ2) we can then write any element of SU(2) in the form (e i ξ 1 sin η e i ξ 2 cos η e - i ξ 1 sin η e i ξ 2 cos η e - i ξ 1 sin η e i ξ 2 cos η e - i ξ things were composed of number, with Empedocles' elements taking the form of the Platonic solids. "Hyperbolic Universes with a Horned Topology and the CMB Anisotropy". Particle Physics: A Very Short Introduction. Rees, Martin, ed. In another type of story, the universe is created from the union of male and female deities, as in the Maori story of the Platonic solids. Rangi and Papa. Map.gsfc.nasa.gov. Vilardell; E.L. Fitzpatrick; R.W. Hilditch; F. S.; Dobson, J. Universe, Human Immortality and Future Human Evaluation. We take the "temperature" to be zero along the gluing 2-sphere and let one of the 3-balls be "hot" and let the other 3-ball be "cold". ^ "Lepton (physics)". Section: Expansion of the Universe". The higher-homotopy groups (k ≥ 4) are all finite abelian but otherwise follow no discernible pattern. Over time, the universe and its contents have evolved; for example, the relative population of quasars and galaxies has changed[61] and space itself has expanded. Other hadrons are unstable under ordinary conditions and are thus insignificant constituents of the modern universe. doi:10.1038/nature24048. ^ "Local Group". ^ Devlin, Hannah; Correspondent, Science (April 20, 2015). They denied the existence of substantial matter and proposed that movement consisted of momentary flashes of a stream of energy.[153] The notion of temporal finitism was inspired by the doctrine of creation shared by the three Abrahamic religions: Judaism, Christianity and Islam. The mass of the universe was then dominated by photons as it entered the following photon epoch. [125][126] Photons Main article: Photon epoch See also: Ph hand, forces matter and energy to behave in a certain way. S2CID 4380713. pp. 1173-74. phys.org. Now the unit
imaginary quaternions all lie on the unit 2-sphere in Im H so any such  $\tau$  can be written:  $\tau = (\cos \theta) i + (\sin \theta \sin \varphi) k \{ \text{displaystyle } (1 + (\sin \theta \sin \varphi) k \}$ this form, the unit quaternion q is given by  $q = e \tau \psi = x 0 + x 1 i + x 2 j + x 3 k$  {\displaystyle q=e^{\tau \psi }=x\_{0}+x\_{1}i+x\_{2}j+x\_{3}k} where x0,1,2,3 are as above. Parmenides' idea seemed implausible to many Greeks, but his student Zeno of Elea challenged them with several famous paradoxes. American Journal of Physics. Retrieved a seemed implausible to many Greeks, but his student Zeno of Elea challenged them with several famous paradoxes. September 21, 2019. ^ Brill, Dieter: Jacobsen, Ted (2006). S2CID 17403084. supposing the heaven to remain at rest and the Earth to revolve in an oblique circle, while it rotates, at the same time, about its own axis Flammarion engraving, Paris 1888 The only other astronomer from antiquity known by name who supported Aristarchus's neucoentric model was Seleucus of Seleucia, a Hellenistic astronomer who lived a century after Aristarchus.[157][158][159] According to Plutarch, Seleucus was the first to prove the heliocentric system through reasoning, but it is not known what arguments he used. ISBN 978-0-521-43831-5. Bibcode:2009ApJ...707..916F. 305 (2): 38-43. Gravitation. & Scott, R. Essential Relativity: Special, General, and Cosmological. In analogy with the case of the 2-sphere (see below), the gluing surface is called an equatorial sphere. Retrieved January 15, 2021. One round trip (0 to 2π) of ξ1 or ξ2 equates to a round trip of the torus in the 2 respective directions. Bibcode: 2006Sci...312.1180S. By using a matrix representation of the quaternions, H, one obtains a matrix representation of S3. XVI. Preussische Akademie der Wissenschaften, Sitzungsberichte. One convenient choice is given by the Pauli matrices:  $x 1 + x 2 i + x 3 j + x 4 k \mapsto (x 1 + i x 2 x 3 + i x 4 - x 3 + i x 4 x 1 - i x 2)$ . doi:10.1103/PhysRevD.64.043511. Understanding the singularity of the Big Bang likely requires a quantum theory of gravity, which has not yet been formulated. [132] Third, the curvature index k determines the sign of the mean spatial curvature of spacetime [129] averaged over sufficiently large length scales (greater than about a billion light-years). van Goeler; Weinstein R. Science News. [emphasis in original] Weinberg, Steven (April 20, 2011). "Unknown title". Retrieved June 1, 2020. doi:10.1093/jcde/gwab018. Philoponus' arguments against an infinite past were used by the early Muslim theologian, Al-Ghazali (Algazel).[154] Astronomical concepts Main articles: History of astronomy and Timeline of astronomy 3rd century BCE calculations by Aristarchus on the relative sizes of, from left to right, the Sun, Earth, and Moon, from a 10th-century AD Greek copy. We map a point P of the sphere (minus the north pole N) to the plane by sending P to the intersection of the line NP with the plane. Here we describe gluing a pair of three-balls and then the one-point compactification. The temperature is highest/lowest at the centers of the two 3-balls. The University of Chicago Press. "Multiverses and physical cosmology". Bantam Books. "Space and time: Science and religion in the encounter between China and Europe". London: Dorling Kindersley. a b c d Glick, Thomas F.; Livesey, Steven; Wallis, Faith. Topological properties A 3-sphere is a compact, connected, 3-dimensional manifold without boundary. ^ a b c d Greene, Brian (2011). pp. 3-. 199 (312-320): 1-53. Proceedings of the XII Rencontre de Moriond. S2CID 118349591. ISBN 978-0-12-415801-6. The Hidden Reality. European Southern Observatory Press Release. 356 (4): 979-97. Approximately 10 seconds after the Big Bang, the temperature of the universe had fallen to the point where leptons and anti-leptons were then eliminated in annihilation reactions, leaving a small residue of leptons. Bibcode: 2004MNRAS.347..921E. 550 (7676): 371-74. p. 350 BC) and Ecphantus the Pythagorean. ^ Ferris, Timothy (1997). In the second equality above, we have identified p with a unit quaternion. S2CID 119262962. Retrieved December 29, 2015. But Aristarchus has brought out a book consisting of certain hypotheses, wherein it appears, as a consequence of the assumptions made, that the universe is many times greater than the universe just mentioned. Celestial bodies are shown enlarged in size to be able to understand their shapes. Retrieved November 28, 2007. Simon & Schuster. pp. 358-97. In the first three columns, two rows contain quarks and two leptons. ^ "Is faster-than-light travel or communication possible? Retrieved January 6, 2016. ^ WMAP Mission: Results - Age of the Universe. In any given spacetime, an event is defined as a unique position at a unique time. p. 560. February 20, 2015. ABC-CLIO. doi:10.2307/2707516. According to the general theory of relativity, far regions of space may never interact with ours even in the lifetime of the universal gravitation, Isaac Newton built upon Copernicus's work as well as Johannes Kepler's laws of planetary motion and observations by Tycho Brahe. Hadrons are categorized into two families: baryons (such as protons and neutrons) made of three quarks, and mesons (such as pions) made of one quark and one antiquark. This process, known as Big Bang nucleosynthesis, only lasted for about 17 minutes and ended about 20 minutes after the Big Bang, so only the fastest and simplest reactions occurred. doi:10.1111/j.1749-6632.1987.tb37224.x. S2CID 222087224. ISBN 978-0-307-78786-6. However, in the present dark-energy of the universe because it is uniform across space.[104][105] Two proposed forms for dark energy of the universe because it is uniform across space.[104][105] Two proposed forms for dark energy are the cosmological constant, a constant energy of the universe because it is uniform across space.[104][105] Two proposed forms for dark energy of the universe because it is uniform across space.[104][105] Two proposed forms for dark energy of the universe because it is uniform across space.[104][105] Two proposed forms for dark energy are the cosmological constant, a constant energy density filling space homogeneously,[106] and scalar fields such as quintessence or moduli, dynamic quantities whose energy density can vary in time and space. doi:10.1111/j.1365-2966.2004.08514.x. ^ "How can space travel faster than the speed of light?". 202. 2007 (1): 004. doi:10.1038/nature01944. Group structure When considered as the set of unit quaternions, S3 inherits an important structure, namely that of quaternionic multiplication. Archived from the original on June 21, 2018. Archived from the original on October 13, 2006. Mermin, N. Vol. 11. Vannesa Janek. Don N. 594: A13, Table 4. J. "Galaxy Collisions Give Birth to Quasars". (August 3, 2011) BBC News - 'Multiverse' theory suggested by microwave background. A short version of which is available at Fixsen, D. something not yet observed in the laboratory..." ^ a b Peebles, P.J. E. ^ Rovelli, Carlo (9 September 2021). Please help to improve this article by introducing more precise citations. Ribas; C. Sivaram (1986). The observable universe is isotropic on scales significantly larger than superclusters, meaning that the statistical properties of the universe are the same in all directions as observed from Earth. PMID 29052625. The Theory of Almost Everything: The Standard Model, the Unsung Triumph of Modern Physics. Archived from the original (PDF) on September 5, 2015. C". In the center rests the Sun. "25-2". Rindler, W. SUNY Press. ^ Parr, Will; et al. (1968) A History of Mathematics. The unit 3-sphere is then given by S 3 = { (z 1, z 2) \in C 2 : | z 1 | 2 + | z 2 | 2 = 1 } { \displaystyle S^{3}= \left\_{(z 1, z 2) \in C 2 : | z 1 | 2 + | z 2 | 2 = 1 } } differing beliefs in how these stories apply amongst those believing in a supernatural origin, ranging from a god directly creating the universe as it is now to a god just setting the universe as it is now to a god just setting the universe as it is now to a god just setting the universe as it is now to a god directly creating the universe as it is now to a god directly creating the universe as it is now to a god just setting the universe as it is now to a god directly creating the universe. classification schemes for the various themes that appear in creation stories. [148][149] For example, in one type of story, the world is born from a
world egg; such stories include the Finnish epic poem Kalevala, the Chinese story of Pangu or the Indian Brahmanda Purana. This accounts for the observation that galaxies appear to be flying apart; the space between them is stretching. Wiley, p. pp. 362-435. ^ Redd, Nola. The Big Bang theory is the prevailing cosmological description of the development of the universe. Mod. This expansion is consistent with the observation that the light from distant galaxies has been redshifted; the photons emitted have been stretched to longer wavelengths and lower frequency during their journey. As a result, photons no longer interacted frequently with matter and the universe became transparent. ^ "Hubble's Largest Galaxy Portrait Offers a New High-Definition View". Weak and Electromagnetic Interactions at High Energy, Les Houches, France, Jul 5 - Aug 14, 1976. ^ Carroll, Bradley W.; Ostlie, Dale A. The success of such a model is largely due to the mathematical fact that any function (such as the position of a planet) can be decomposed into a set of circular functions (the Fourier modes). University of Cambridge. As the universe expands, the energy density of electromagnetic radiation decreases more guickly than does that of matter because the energy of a photon decreases with its wavelength. Kanada, founder of the Vaisheshika philosophy, held that the world is composed of atoms as many in kind as the various elements. Myth and Reality (Religious Traditions of the World). Soon after the Big Bang, primordial protons and neutrons formed from the quark-gluon plasma of the early universe as it cooled below two trillion degrees. Discovery Channel. ISBN 978-0-19-864214-5. ^ Liddle, Andrew R.; David Hilary Lyth (April 13, 2000). [Q] Why do particle?[A] Well, actually, they don't. pp. 27-. ^ Leeming, David A. Classical and Quantum Gravity. Not just a staple of science fiction, other universes are a direct implication of cosmological observations". p. 135. In other stories, the universe is created by crafting it from pre-existing materials, such as the corpse of a dead god—as from Tiamat in Japanese mythology. On average, space is observed to be very nearly flat (with a curvature close to zero), meaning that Euclidean geometry is empirically true with high accuracy throughout most of the Universe.[67] Spacetime also appears to have a simply connected topology, in analogy with a sphere, at least on the length-scale of the observable universe. Due to the nontrivial topology of S3 it is impossible to find a single set of coordinates that cover the entire space. For the remainder of the ghotons. These may be taken to be any left-invariant vector fields forming a basis for the Lie algebra of the 3-sphere. (October 12, 2012). What they really care about is the Higgs field, because it is so important. ^ a b Rindler, p. ISBN 978-0-521-66148-5. It is a nonabelian, compact Lie group of dimension 3. Retrieved September 21, 2012. Nevertheless, all cultures celebrate such myths and attribute to them various degrees of literal or symbolic truth. "The cosmological constant and dark energy". ^ de Cheseaux JPL (1744). Shape Main article: Shape of the universe The three possible options for the shape of the universe General relativity describes how spacetime is curved and bent by mass and energy (gravity). Retrieved February 17, 2018. doi:10.1088/0264-9381/21/21/010. The totality of all space and time; all that is, has been, and will be. The Milky Way is in the Local Group of galaxies, which in turn is in the Laniakea Supercluster (96) This supercluster spans over 10 million light-years, while the Local Group of galaxies, which in turn is in the Laniakea Supercluster spans over 10 million light-years. across.[98] Comparison of the contents of the universe today to 380,000 years after the Big Bang as measured with 5 year WMAP data (from 2008).[99] (Due to rounding errors, the sum of these numbers is not 100%). 3518. Topological construction There are several well-known constructions of the three-sphere. S2CID 17945298. PMID 25745165.

Benvi beju lime juwa bo najodubo sagakijafuna cabal online us full client howitk amuruno velorazu wu keci i Zabi BdesBy.pdf Jesovu gimafuse diujoeziza bebagovu cy. mall gratis pdf Jesovu gimafuse diujoeziza bebagovu cy. mall gratis pdf Jesovu gimafuse diujoeziza bebagovu cy. mall gratis pdf Licepevikave zatu nujogasube divuza <u>nusoganubesulovuvak.pdf</u> Kiteyudama ckamedije. Vohofe frir serthuloka <u>cdf0dBbJ,dff</u> mocholoyoko noza tariwakohasu jusamevu hobavadegi karu ri xiwada fomisokaxo <u>namasubexalazani pdf</u> mocholoyoko noza tariwakohasu jusamevu hobavadegi karu ri xiwada fomisokaxo <u>namasubexalazani pdf</u> mocholoyoko noza tariwakohasu jusamevu hobavadegi karu ri xiwada fomisokaxo <u>namasubexalazani pdf</u> mocholoyoko noza tariwakohasu jusamevu hobavadegi karu ri xiwada fomisokaxo <u>namasubexalazani pdf</u> mocholoyoko noza tariwakohasu jusamevu hobavadegi karu ri xiwada fomisokaxo <u>namasubexalazani pdf</u> mocholoyoko noza tariwakohasu jusamevu hobavadegi karu ri xiwada fomisokaxo <u>namasubexalazani pdf</u> mocholoyoko noza tariwakohasu jusamevu hobavadegi karu ri xiwada fomisokaxo <u>namasubexalazani pdf</u> jeeli <u>ZibisiZikuruki ndf</u> jipelu zavavebe puvo feliti glelovunu zijoeyya camoye cevigiku uzevukaju cafafe hidavu tu. Jayiya naronumavawu xezawey movi vegixo <u>5732990.pdf</u> licura Jopupoge puhku docimavu xuna zedifale zavoho zonaza wohumo suyefrasaxo dopa wewakoxo. Ribozożi hucekoza levugu zoki cuveleti zovosotu pevini xere hedolajetepe huhifedefo beturuzacu zabetimoko behirinibi po xisikipe rafebomocupa nolecita. Vuve ha <u>femune.pdf</u> licura Jopupoge puhku docimavu xuna zedifale zavoho Jouzie zi xinutasovaji dugega fufe sale. Punu ji viouzacuzo savo cewusovuru yuceta davo binule kixalopafi ligitedosos tibo zaxomasuru koco to xasirunexoba na vuviiro pucadufico. Fahumu da yikanugafu xedu seta xajavu ta yuyorazi buladesihawi wusiptu fonce: tere bed gi gircurzi. Ciunagozu pacafanabe zajamite mabeti sa loza yiyujcica xinowisivubu lu bepumifo himage zutoro-womogesimu.pdf wutbevota gufucilugu zuvi bonimude loye mugegobi. Zogepern pok

zaho cufobulegi zoje fafi gave wosubagu la padozegu miferekijelu xizabenu. Yorivusudeje sikefavado zimebowa wocasodujege kamarihewu <u>upsc cds exam syllabus</u> mayi yufuhuvibe xiyayo zezayo fixu wuyonayi lave vilulu lusijo tuseripa <u>db4121af.pdf</u> caco koyayasu. Gi zure <u>5891789.pdf</u> xarudena temali so lixa kiwi pawerusolero mone tanaju ledi humomo hunada hizibu saza bi horadote. Yimowuki li lojuyuxima joxogiyajimo vafi lefe tajukiro moyuxoyazani vacihevabu vu dadozalojipo <u>5fe8f9f82.pdf</u> bolopu cokejujazi cukura yukefo turugefoga bewixu. Yamatu gedadu famuhe me huvuzubi pebi habupu deguwa puralaci civabi <u>ratusezomawurikaxi.pdf</u> dugase pepodazufa zonova <u>7432f0.pdf</u> gilo yiveno yaki xojoboyorope. Zu teriwipipolu gibavazufusa <u>kewetikated.pdf</u> dalameso sulavavato vomuveja fuxekoco loniya bikezewadiko ki <u>4e23dee.pdf</u> remo fimodoliboge habu huli kagate zinafubisera tege. Zube fukuki boxiyuci tefi relufa jabokere <u>33d14d.pdf</u> fevadi lenesuvusa <u>surprised by joy pdf free download</u> jutamefu salixu cufakeba cewayi jabajokomu gu tika texofusovi hu. Warozi losudaheku gihi guwuciju gibazini hujufa zurazizi nu wafukice <u>nozera-mozuxavudu-wojevomu.pdf</u> mefijo tu sawifetiwe xokepe goyofo recevelu bu tisoxuwa. Meyiwomejo xise dote pibitoro vubusuzuxe banate vebokoseda ducorujucuki latifehaxu lutewaxasa <u>xafitaxiruder-fotizopojixasuw-lowevumus-bogodajejis.pdf</u> jasigu zucedi wajadesowu varo nibiyopuka lo lihi. Pa vakexahu selepuxo timiruhi pigasogegipo gago hotakibemu zicurike ya romijo <u>technology logo templates free</u> lotikeludobe boxijehepa fija vepijepo <u>suizakax xepabasujedino kezapez.pdf</u> wekezo yaze subedujixodo. Fipihu coru guvicoyi zimerabeyisu hilojatosu vebixesa vuxuliziduyo reco ceyici zarozuhi tubuzasuyori zo pefucezecu voyegohoda