Chapter 1 : Ultimate Physics: From Quarks to the Cosmos - Scientific American

In particle physics, scientists study the properties of the smallest bits of matter and how they interact. Another branch of physicsâ€"astrophysicsâ€"creates and tests theories about what's happening across our vast universe.

In particle physics, scientists study the properties of the smallest bits of matter and how they interact. While particle physics and astrophysics appear to focus on opposite ends of a spectrum, scientists in the two fields actually depend on one another. Several current lines of inquiry link the very large to the very small. The seeds of cosmic structure For one, particle physicists and astrophysicists both ask questions about the growth of the early universe. In her office at Stanford University, Eva Silverstein explains her work parsing the mathematical details of the fastest period of that growth, called cosmic inflation. This process released previously trapped photonsâ€"elementary particles of light. The glow from that light, called the cosmic microwave background, lingers in the sky today. Scientists measure different characteristics of the cosmic microwave background to learn more about what happened in those first moments after the Big Bang. Places that were dense with subatomic particlesâ€"or even just virtual fluctuations of subatomic particlesâ€"attracted more and more matter. As the universe grew, these areas of density became the locations where galaxies and galaxy clusters formed. The very small grew up to be the very large. Scientists studying the cosmic microwave background hope to learn about more than just how the universe grewâ€"it could also offer insight into dark matter, dark energy and the mass of the neutrino. Astrophysicists want to know what made up the early universe and what makes up our universe today. Particle physicists want to know whether there are undiscovered particles and forces out there for the finding. These observations indicate that the universe is made up of roughly 5 percent normal matter, 25 percent dark matter and 70 percent dark energy. But to date, scientists have not directly observed dark energy or dark matter. Over the past several years, the number of models of dark matter has been expanding, along with the number of ways to detect it, says Tom Rizzo, a senior scientist at SLAC and head of the theory group. Some experiments search for direct evidence of a dark matter particle colliding with a matter particle in a detector. Others look for indirect evidence of dark matter particles interfering in other processes or hiding in the cosmic microwave background. If dark matter has the right properties, scientists could potentially create it in a particle accelerator such as the Large Hadron Collider. Physicists are also actively hunting for signs of dark energy. It is possible to measure the properties of dark energy by observing the motion of clusters of galaxies at the largest distances that we can see in the universe. For particle physicists, gravity is the one basic force of nature that the Standard Model does not quite explain. Astrophysicists want to understand the important role gravity played and continues to play in the formation of the universe. The strong force has gluons. The weak force has W and Z bosons. When particles interact through a force, they exchange these force-carriers, transferring small amounts of information called quanta, which scientists describe through quantum mechanics. General relativity explains how the gravitational force works on large scales: Earth pulls on our own bodies, and planetary objects pull on each other. But it is not understood how gravity is transmitted by quantum particles. Discovering a subatomic force-carrier particle for gravity would help explain how gravity works on small scales and inform a quantum theory of gravity that would connect general relativity and quantum mechanics. Compared to the other fundamental forces, gravity interacts with matter very weakly, but the strength of the interaction quickly becomes larger with higher energies. Theorists predict that at high enough energies, such as those seen in the early universe, quantum gravity effects are as strong as the other forces. Gravity played an essential role in transferring the small-scale pattern of the cosmic microwave background into the large-scale pattern of our universe today. Our understanding of gravity is also key in the search for dark matter. Big ideas, tiny details Learning more about gravity could tell us about the dark universe, which could also reveal new insight into how structure in the universe first formed. As scientists probe space and go back further in time, they can learn more about the rules that govern physics at high energies, which also tells us something about the smallest components of our world. Artwork for this article is available as a printable poster.

Chapter 2 : particles | The Cosmos

Editorial - From Particles to the Cosmos at EPS HEP in Venice By Yves calendrierdelascience.comhed on 26 September in: Editorial, September , , Conference, EPS HEPP Division, EPS-HEP, High energy physics, Particle Physics.

What can particles tell us about the cosmos? The minuscule and the immense can reveal quite a bit about each other. In particle physics, scientists study the properties of the smallest bits of matter and how they interact. While particle physics and astrophysics appear to focus on opposite ends of a spectrum, scientists in the two fields actually depend on one another. Several current lines of inquiry link the very large to the very small. The seeds of cosmic structure For one, particle physicists and astrophysicists both ask questions about the growth of the early universe. In her office at Stanford University, Eva Silverstein explains her work parsing the mathematical details of the fastest period of that growth, called cosmic inflation. This process released previously trapped photonsâ€"elementary particles of light. The glow from that light, called the cosmic microwave background, lingers in the sky today. Scientists measure different characteristics of the cosmic microwave background to learn more about what happened in those first moments after the Big Bang. Places that were dense with subatomic particlesâ€"or even just virtual fluctuations of subatomic particlesâ€"attracted more and more matter. As the universe grew, these areas of density became the locations where galaxies and galaxy clusters formed. The very small grew up to be the very large. Scientists studying the cosmic microwave background hope to learn about more than just how the universe grewâ€"it could also offer insight into dark matter, dark energy and the mass of the neutrino. Astrophysicists want to know what made up the early universe and what makes up our universe today. Particle physicists want to know whether there are undiscovered particles and forces out there for the finding. These observations indicate that the universe is made up of roughly 5 percent normal matter, 25 percent dark matter and 70 percent dark energy. But to date, scientists have not directly observed dark energy or dark matter. Over the past several years, the number of models of dark matter has been expanding, along with the number of ways to detect it, says Tom Rizzo, a senior scientist at SLAC and head of the theory group. Some experiments search for direct evidence of a dark matter particle colliding with a matter particle in a detector. Others look for indirect evidence of dark matter particles interfering in other processes or hiding in the cosmic microwave background. If dark matter has the right properties, scientists could potentially create it in a particle accelerator such as the Large Hadron Collider. Physicists are also actively hunting for signs of dark energy. It is possible to measure the properties of dark energy by observing the motion of clusters of galaxies at the largest distances that we can see in the universe. For particle physicists, gravity is the one basic force of nature that the Standard Model does not quite explain. Astrophysicists want to understand the important role gravity played and continues to play in the formation of the universe. The strong force has gluons. The weak force has W and Z bosons. When particles interact through a force, they exchange these force-carriers, transferring small amounts of information called quanta, which scientists describe through quantum mechanics. General relativity explains how the gravitational force works on large scales: Earth pulls on our own bodies, and planetary objects pull on each other. But it is not understood how gravity is transmitted by quantum particles. Discovering a subatomic force-carrier particle for gravity would help explain how gravity works on small scales and inform a quantum theory of gravity that would connect general relativity and quantum mechanics. Compared to the other fundamental forces, gravity interacts with matter very weakly, but the strength of the interaction quickly becomes larger with higher energies. Theorists predict that at high enough energies, such as those seen in the early universe, quantum gravity effects are as strong as the other forces. Gravity played an essential role in transferring the small-scale pattern of the cosmic microwave background into the large-scale pattern of our universe today. Our understanding of gravity is also key in the search for dark matter. Big ideas, tiny details Learning more about gravity could tell us about the dark universe, which could also reveal new insight into how structure in the universe first formed. As scientists probe space and go back further in time, they can learn more about the rules that govern physics at high energies, which also tells us something about the smallest components of our world.

Chapter 3 : What can particles tell us about the cosmos? | symmetry magazine

Subatomic particles: Electrons (-), Protons (+), and Neutrons (neutral) The mass of a proton is times the mass of an electron; the mass of a proton is approximately equal to the mass of a neutron.

When infrared astronomy began, the dust particles were observed to be significant and vital components of astrophysical processes. Their analysis can reveal information about phenomena like the formation of the Solar System. Zodiacal light caused by cosmic dust. The evolution of dust traces out paths in which the Universe recycles material, in processes analogous to the daily recycling steps with which many people are familiar: Slightly changing any of these parameters can give significantly different dust dynamical behavior. Therefore, one can learn about where that object came from, and what is in the intervening medium. Detection methods[edit] Cosmic dust of the Andromeda Galaxy as revealed in infrared light by the Spitzer Space Telescope. Cosmic dust can be detected by indirect methods that utilize the radiative properties of the cosmic dust particles. Don Brownlee at the University of Washington in Seattle first reliably identified the extraterrestrial nature of collected dust particles in the latter s. Another source is the meteorites , which contain stardust extracted from them. Stardust grains are solid refractory pieces of individual presolar stars. They are recognized by their extreme isotopic compositions, which can only be isotopic compositions within evolved stars, prior to any mixing with the interstellar medium. These grains condensed from the stellar matter as it cooled while leaving the star. In interplanetary space, dust detectors on planetary spacecraft have been built and flown, some are presently flying, and more are presently being built to fly. Instead, in-situ dust detectors are generally devised to measure parameters associated with the high-velocity impact of dust particles on the instrument, and then derive physical properties of the particles usually mass and velocity through laboratory calibration i. Over the years dust detectors have measured, among others, the impact light flash, acoustic signal and impact ionisation. Recently the dust instrument on Stardust captured particles intact in low-density aerogel. The collected dust at Earth or collected further in space and returned by sample-return space missions is then analyzed by dust scientists in their respective laboratories all over the world. Infrared light can penetrate the cosmic dust clouds, allowing us to peer into regions of star formation and the centers of galaxies. During its mission, Spitzer will obtain images and spectra by detecting the infrared energy, or heat, radiated by objects in space between wavelengths of 3 and micrometres. The findings from the Spitzer already revitalized the studies of cosmic dust. A recent report from a Spitzer team shows some evidence that cosmic dust is formed near a supermassive black hole. Dust grains are not spherical and tend to align to interstellar magnetic fields, preferentially polarising starlight that passes through dust clouds. In nearby interstellar space, where cosmic reddening is not sensitive enough to be detected, high precision optical polarimetry has been used to glean the structure of dust within the Local Bubble. Furthermore, we have to specify whether the emissivity process is extinction , scattering , absorption , or polarisation. In the radiation emission curves, several important signatures identify the composition of the emitting or absorbing dust particles. Dust particles can scatter light nonuniformly. The scattering and extinction "dimming" of the radiation gives useful information about the dust grain sizes. In X-ray wavelengths, many scientists are investigating the scattering of X-rays by interstellar dust, and some have suggested that astronomical X-ray sources would possess diffuse haloes, due to the dust. Presolar grains Stardust grains also called presolar grains by meteoriticists [22] are contained within meteorites, from which they are extracted in terrestrial laboratories. Stardust was a component of the dust in the interstellar medium before its incorporation into meteorites. The meteorites have stored those stardust grains ever since the meteorites first assembled within the planetary accretion disk more than four billion years ago. So-called carbonaceous chondrites are especially fertile reservoirs of stardust. Each stardust grain existed before the Earth was formed. Stardust is a scientific term referring to refractory dust grains that condensed from cooling ejected gases from individual presolar stars and incorporated into the cloud from which the Solar System condensed. These refractory mineral grains may earlier have been coated with volatile compounds, but those are lost in the dissolving of meteorite matter in acids, leaving only insoluble refractory minerals. Finding the grain cores without dissolving most of the meteorite has been possible, but difficult and labor-intensive see presolar grains. Many new aspects of nucleosynthesis have been discovered from the isotopic ratios within the stardust grains. Prominent are silicon carbide , graphite , aluminium oxide , aluminium spinel , and other such solids that would condense at high temperature from a cooling gas, such as in stellar winds or in the decompression of the inside of a supernova. They differ greatly from the solids formed at low temperature within the interstellar medium. Also important are their extreme isotopic compositions, which are expected to exist nowhere in the interstellar medium. This also suggests that the stardust condensed from the gases of individual stars before the isotopes could be diluted by mixing with the interstellar medium. These allow the source stars to be identified. For example, the heavy elements within the silicon carbide SiC grains are almost pure S-process isotopes, fitting their condensation within AGB star red giant winds inasmuch as the AGB stars are the main source of S-process nucleosynthesis and have atmospheres observed by astronomers to be highly enriched in dredged-up s process elements. SUNOCONs contain in their calcium an excessively large abundance [26] of 44Ca, demonstrating that they condensed containing abundant radioactive 44Ti, which has a year half-life. The outflowing 44Ti nuclei were thus still "alive" radioactive when the SUNOCON condensed near one year within the expanding supernova interior, but would have become an extinct radionuclide specifically 44Ca after the time required for mixing with the interstellar gas. The high interest in stardust derives from new information that it has brought to the sciences of stellar evolution and nucleosynthesis. Laboratories have studied solids that existed before the Earth was formed. The existence of stardust proved this historic picture incorrect. Some bulk properties[edit] Smooth chondrite interplanetary dust particle. Cosmic dust is made of dust grains and aggregates of dust grains. These particles are irregularly shaped, with porosity ranging from fluffy to compact. General diffuse interstellar medium dust, dust grains in dense clouds , planetary rings dust, and circumstellar dust , are each different in their characteristics. For example, grains in dense clouds have acquired a mantle of ice and on average are larger than dust particles in the diffuse interstellar medium. Interplanetary dust particles IDPs are generally larger still. Major elements of stratospheric interplanetary dust particles. Most of the influx of extraterrestrial matter that falls onto the Earth is dominated by meteoroids with diameters in the range 50 to micrometers, of average density 2. In circumstellar dust, astronomers have found molecular signatures of CO , silicon carbide , amorphous silicate , polycyclic aromatic hydrocarbons , water ice , and polyformaldehyde , among others in the diffuse interstellar medium , there is evidence for silicate and carbon grains. Cometary dust is generally different with overlap from asteroidal dust. Asteroidal dust resembles carbonaceous chondritic meteorites. Cometary dust resembles interstellar grains which can include silicates, polycyclic aromatic hydrocarbons, and water ice. Dust grain formation[edit] The large grains in interstellar space are probably complex, with refractory cores that condensed within stellar outflows topped by layers acquired subsequently during incursions into cold dense interstellar clouds. That cyclic process of growth and destruction outside of the clouds has been modeled [31] [32] to demonstrate that the cores live much longer than the average lifetime of dust mass. Those cores mostly start with silicate particles condensing in the atmospheres of cool oxygen rich red-giant stars and carbon grains condensing in the atmospheres of cool carbon stars. The red-giant stars have evolved off the main sequence and have entered the giant phase of their evolution and are the major source of refractory dust grain cores in galaxies. Those refractory cores are also called Stardust section above , which is a scientific term for the small fraction of cosmic dust that condensed thermally within stellar gases as they were ejected from the stars. Several percent of refractory grain cores have condensed within expanding interiors of supernovae, a type of cosmic decompression chamber. And meteoriticists that study this refractory stardust extracted from meteorites often call it presolar grains , although the refractory stardust that they study is actually only a small fraction of all presolar dust. Stardust condenses within the stars via considerably different condensation chemistry than that of the bulk of cosmic dust, which accretes cold onto preexisting dust in dark molecular clouds of the galaxy. Those molecular clouds are very cold, typically less than 50K, so that ices of many kinds may accrete onto grains, perhaps to be destroyed later. Finally, when the Solar System formed, interstellar dust grains were further modified by chemical reactions within the planetary accretion disk. So the history of the complex grains in the early Solar System is complicated and only partially understood. Astronomers know that the dust is formed in the envelopes of late-evolved stars from specific observational signatures. In infrared light, emission at 9. These help provide evidence that the small silicate particles in space came from the ejected outer envelopes of these stars. This would take excessive time to accomplish, even if it might be possible. The arguments are that: So mass loss from stars is unquestionably where the refractory cores of grains formed. Some molecules, for example, graphite C and SiC would condense into solid grains in the planetary disk; but carbon and SiC grains found in meteorites are presolar based on their isotopic compositions, rather than from the planetary disk formation. Some molecules also formed complex organic compounds and some molecules formed frozen ice mantles, of which either could coat the "refractory" Mg, Si, Fe grain cores. Stardust once more provides an exception to the general trend, as it appears to be totally unprocessed since its thermal condensation within stars as refractory crystalline minerals. The condensation of graphite occurs within supernova interiors as they expand and cool, and do so even in gas containing more oxygen than carbon, [36] a surprising carbon chemistry made possible by the intense radioactive environment of supernovae. This special example of dust formation has merited specific review. Some materials could only have been formed at high temperatures, while other grain materials could only have been formed at much lower temperatures. The materials in a single interplanetary dust particle often show that the grain elements formed in different locations and at different times in the solar nebula. Most of the matter present in the original solar nebula has since disappeared; drawn into the Sun, expelled into interstellar space, or reprocessed, for example, as part of the planets, asteroids or comets. Due to their highly processed nature, IDPs interplanetary dust particles are fine-grained mixtures of thousands to millions of mineral grains and amorphous components. From the solar nebula to Earth[edit] A dusty trail from the early Solar System to carbonaceous dust today. The arrows in the adjacent diagram show one possible path from a collected interplanetary dust particle back to the early stages of the solar nebula. We can follow the trail to the right in the diagram to the IDPs that contain the most volatile and primitive elements. The trail takes us first from interplanetary dust particles to chondritic interplanetary dust particles. Planetary scientists classify chondritic IDPs in terms of their diminishing degree of oxidation so that they fall into three major groups: As the name implies, the carbonaceous chondrites are rich in carbon, and many have anomalies in the isotopic abundances of H, C, N, and O Jessberger, [citation needed]. From the carbonaceous chondrites, we follow the trail to the most primitive materials. They are almost completely oxidized and contain the lowest condensation temperature elements "volatile" elements and the largest amount of organic compounds. Therefore, dust particles with these elements are thought to be formed in the early life of the Solar System. The volatile elements have never seen temperatures above about K, therefore, the IDP grain "matrix" consists of some very primitive Solar System material. Such a scenario is true in the case of comet dust. Nuclear damage tracks are caused by the ion flux from solar flares.

Chapter 4 : Ghost Particles Give Scientists A New Understanding Of The Cosmos

The new ordering of the particles explained many of the properties of the newly discovered particles, as well as correctly predicting some new ones. These 17 fundamental particles make up the.

Neutrinos Ghostly Particles remain undisturbed even by the strongest magnetic fields Reuters Washington, United States: A breakthrough in the study of ghostly particles called high-energy neutrinos that traverse space, zipping unimpeded through people, planets and whole galaxies, is giving scientists an audacious new way to expand our understanding of the cosmos. Researchers on Thursday said they have for the first time located a deep-space source for these ubiquitous subatomic particles. Artistic impression of the galatic nucleus showing the black hole. Astronomers long have relied upon electromagnetic observations - studying light - but this approach has limitations because too many aspects of the universe are indecipherable using light alone. The ability to use particles like high-energy neutrinos in astronomy enables a more robust examination, much as the confirmation of ripples in the fabric of space-time called gravitational waves, announced in , opened another new frontier in astronomy. This emerging field is dubbed "multi-messenger astrophysics. They can essentially escape their site of production and bring that information directly across the cosmos to their point of detection. The findings solve a mystery dating to over the source of subatomic particles like neutrinos and cosmic rays that dash through the cosmos. As charged particles, cosmic rays cannot be traced straight back to their source because strong magnetic fields in space alter their trajectory. Neutrinos are electrically neutral, undisturbed by even the strongest magnetic field, and rarely interact with matter, earning the nickname "ghost particle. The IceCube neutrino detector involves 86 holes drilled 8, feet 2, meters into the Antarctic ice. Some 5, light sensors register small flashes of light produced during rare instances when a neutrino collides with an atomic nucleus in the transparent ice. The key detection came on Sept. Scientists then determined that other neutrinos earlier detected by IceCube originated from the same source. Not all neutrinos are the high-energy variety. Lower-energy neutrinos, for example, are produced prolifically in the fusion processes of stars like our sun. Blazars are probably not the only sources for high-energy neutrinos or high-energy cosmic rays, Grant said, mentioning other objects and phenomena like galactic nuclei, quasars, gamma ray bursts and some types of stellar explosions called supernovas. National Science Foundation-supported research was published in the journal Science. NDTV Beeps - your daily newsletter.

DOWNLOAD PDF FROM PARTICLES TO THE COSMOS

Chapter 5 : Cosmic dust - Wikipedia

The cosmos is vast, the largest stuff that exists. Particles are tiny, the smallest stuff that exists. Yet the particles compose the cosmos; there is nothing in the cosmos other than the particles, and the fields and forces that are associated with them. How does the whole system composed of cosmos.

CERN Off A photomicrograph shows where high-energy electrons blazed through a film emulsion located in a spectrometer outside the target chamber for the petawatt laser tests. The tracks are slightly curved from the emulsion being slightly curved in its holder Image: As he ascended to metres, he measured the rate of ionisation in the atmosphere and found that it increased to some three times that at sea level. He concluded that penetrating radiation was entering the atmosphere from above. He had discovered cosmic rays. When they arrive at Earth, they collide with the nuclei of atoms in the upper atmosphere, creating more particles, mainly pions. The charged pions can swiftly decay, emitting particles called muons. Unlike pions, these do not interact strongly with matter, and can travel through the atmosphere to penetrate below ground. A new world of particles Studies of cosmic rays opened the door to a world of particles beyond the confines of the atom: Until the advent of high-energy particle accelerators in the early s, this natural radiation provided the only way to investigate the growing particle "zoo". Indeed, when CERN was founded in , its convention included cosmic rays in the list of scientific interests. But even though accelerators came to provide the best hunting ground for new particles, the physics of cosmic rays is still widely studied. The energies of the primary cosmic rays range from around 1 GeV â€" the energy of a relatively small particle accelerator â€" to as much as TeV, far higher than the beam energy of the Large Hadron Collider. The rate at which these particles arrive at the top of the atmosphere falls off with increasing energy, from about 10 per square metre per second at 1 GeV to less than one per square kilometre per century for the highest energy particles. The very high-energy cosmic rays generate huge showers of up to 10 billion secondary particles or more, which can be picked up by particle detectors when they are spread over areas as large as 20 square kilometres on the surface of the Earth. Cosmic accelerators Just how do cosmic rays reach such high energies? Where are the natural accelerators? The lowest energy cosmic rays arrive from the Sun in a stream of charged particles known as the solar wind, but pinning down the origin of the higher-energy particles is made difficult as they twist and turn in the magnetic fields of interstellar space. Clues have come through studying high-energy gamma rays from outer space. These are far fewer than the charged cosmic rays, but being electrically neutral they are not influenced by magnetic fields. They generate showers of secondary particles that can be detected on Earth and that point back towards the point of origin of the gamma rays. Sources of the highest energy gamma rays in our own galaxy, the Milky Way, include the remnants of supernovae, such as the famous Crab Nebula ; the shock waves from these stellar explosions have long been proposed as possible natural accelerators. Other sources of ultra-high-energy gamma rays lie in other galaxies, where exotic objects such as supermassive black holes may drive the acceleration. There is also evidence that the highest energy charged cosmic rays also have similar origins in other galaxies. An experiment at CERN is using the cleanest box in the world to find out.

Chapter 6 : HenryFest: Tying Particles and Strings to the Cosmos - Cornell

From Quarks to the Cosmos Shane L. Larson Department of Physics Utah State University calendrierdelascience.com@calendrierdelascience.com ATK Â¥ The nature of particles affects the composition and.

A new computer technique has now found hints at where it might be. It shows galaxies pink strung like beads along long filaments of dark matter blue. Most of the ordinary matter is probably stored in gas orange. Some matter has been missing â€" the ordinary type that makes up atoms. Astronomers say they may have found it. Scientists think this missing matter is hot gas. It appears to be lurking in spaces between clusters of galaxies. Previous studies had hinted where this missing matter might be hiding. A new search technique now is helping home in on where it resides. Astronomers described online the technique they used in a pair of papers posted September 15 and 29 at arXiv. The particle zoo Finding this missing matter is important, says Dominique Eckert. He did not take part in the new work. He has, however, searched for the missing matter. It is made of protons, neutrons and other select subatomic particles. Scientists sometimes refer to these as baryons BEAR-ee-ahns. And that starts with knowing where those baryons are. Astronomers know that about 85 percent of the matter in the universe is dark matter. This stuff is mysterious and elusive. In contrast, ordinary matter makes up only about 15 percent of the mass of the universe. It is what is in us and all around us. As they look at galaxies within the nearest few billion light-years from Earth, they find only about half the baryons that should have been produced in the Big Bang. According to current theory, the Big Bang marked the origin of the universe. The rest of the ordinary matter is probably hiding in long strands, or filaments, of gas. These strands connect clusters of galaxies in a vast cosmic web. Previous attempts to find the missing baryons focused on X-rays emitted by the gas. Astronomers also looked at how the light coming out certain of bright, distant galaxies, called quasars, filtered through these cobwebby strands. Still, that missing ordinary matter had remained a no-show. Now some scientists have scouted for the missing matter in a new way. He did this research while working at the University of British Columbia in Vancouver. Anna de Graaff is an astrophysicist in Scotland at the University of Edinburgh. Each group found a way to look through the gas. They peered all of the way back to the oldest light in the universe. Accounting for cosmic clouds That ancient light is known as the cosmic microwave background. It is residual heat that was emitted some , years after the Big Bang. As it beams through space, this light passes through clouds of electrons, which are negatively charged particles. Filaments of hot gas host these electron clouds. As the cosmic microwave background passes through these clouds, they deflect and distort the light in a particular way. In , a satellite helped create an all-sky map of those distortions. Tanimura and de Graaff separately figured that there should be more distortion along the filaments than in empty space. To locate the filaments, both teams focused on pairs of galaxies from a catalog known as the Sloan Digital Sky Survey. The galaxies they chose had to be at least 20 million light-years apart. Both groups assumed that the galaxies were not all part of some galaxy cluster. But they should be connected by a filament. Individually, those filaments were too faint to see. To bring them into view, the teams used computer software. It layered all of the images. Then, each team subtracted out distortions that any clouds of electrons would have produced. This revealed a residual distortion in the cosmic microwave background. Both groups saw it and now link it to the presence of those filaments. Michael Shull is an astrophysicist at the University of Colorado Boulder. It could have been ejected from galaxies at high speeds. Eckert also worries that the gas may belong more to the galaxies than to their intergalactic tethers. Future observations of what the gas is made from, he says, along with more sensitive X-ray observations, could help solve that part of the puzzle. People who work in this field are known as astrophysicists. Protons and neutrons are the best known baryons. It seems to flow in all directions and with an equal intensity. It is estimated to be about 2. People who work in this field are known as cosmologists. They are believed to exist because of unexplained gravitational forces that they appear to exert on other, visible astronomical objects. For instance, the fragile metal wire that heats up to emit light inside an incandescent light bulb is known as its filament. Galaxies, which each typically include between 10 million and trillion stars, also include clouds of gas, dust and the remnants of exploded stars. Galaxy clusters are the largest known objects in the universe. To get some idea of this length, imagine a rope long enough to wrap around the Earth. It would be a little over 40, kilometers 24, miles long. Lay it out straight. Now lay another million more that are the same length, end-to-end, right after the first. The total distance they now span would equal one light-year. Neutrons belong to the family of particles known as hadrons. Protons belong to the family of particles known as hadrons. This is the brilliant core of some galaxy massive collections of stars that contains a super-massive black hole. As mass from the galaxy is pulled into that black hole, a huge quantity of energy is released, giving the quasar its light. Or the process of tying some object to a cord that will keep it loosely affixed to that position. All things that exist throughout space and time. It has been expanding since its formation during an event known as the Big Bang, some

Chapter 7 : Ghostly Particles Gives Scientist Understanding of The Cosmos

The findings solve a mystery dating to over the source of subatomic particles like neutrinos and cosmic rays that dash through the cosmos. It appears they arise from some of the universe's.

Etymology[edit] The term ray is somewhat of a misnomer due to a historical accident, as cosmic rays were at first, and wrongly, thought to be mostly electromagnetic radiation. In common scientific usage, [7] high-energy particles with intrinsic mass are known as "cosmic" rays, while photons , which are quanta of electromagnetic radiation and so have no intrinsic mass are known by their common names, such as gamma rays or X-rays , depending on their photon energy. Massive cosmic rays compared to photons[edit] In current usage, the term cosmic ray almost exclusively refers to massive particles â€" those that have rest mass â€" as opposed to photons , which have no rest mass. Massive particles have additional, kinetic , mass-energy when they are moving, due to relativistic effects. Through this process, some particles acquire tremendously high mass-energies. These are significantly higher than the photon energy of even the highest-energy photons detected to date. The energy of the massless photon depends solely on frequency , not speed, as photons always travel at the same speed. At the higher end of the energy spectrum, relativistic kinetic energy is the main source of the mass-energy of cosmic rays. The precise nature of this remaining fraction is an area of active research. An active search from Earth orbit for anti-alpha particles has failed to detect them. As a result of these discoveries, there has been interest in investigating cosmic rays of even greater energies. However, his paper published in Physikalische Zeitschrift was not widely accepted. In , Domenico Pacini observed simultaneous variations of the rate of ionization over a lake, over the sea, and at a depth of 3 metres from the surface. Pacini concluded from the decrease of radioactivity underwater that a certain part of the ionization must be due to sources other than the radioactivity of the Earth. In , Victor Hess carried three enhanced-accuracy Wulf electrometers [17] to an altitude of 5, metres in a free balloon flight. He found the ionization rate increased approximately fourfold over the rate at ground level. By sheer coincidence, exactly years later on 7 August , the Mars Science Laboratory rover used its Radiation Assessment Detector RAD instrument to begin measuring the radiation levels on another planet for the first time. On 31 May , NASA scientists reported that a possible manned mission to Mars may involve a greater radiation risk than previously believed, based on the amount of energetic particle radiation detected by the RAD on the Mars Science Laboratory while traveling from the Earth to Mars in â€" Bruno Rossi wrote that: In the late s and early s the technique of self-recording electroscopes carried by balloons into the highest layers of the atmosphere or sunk to great depths under water was brought to an unprecedented degree of perfection by the German physicist Erich Regener and his group. To these scientists we owe some of the most accurate measurements ever made of cosmic-ray ionization as a function of altitude and depth. Millikan believed that his measurements proved that the primary cosmic rays were gamma rays; i. And he proposed a theory that they were produced in interstellar space as by-products of the fusion of hydrogen atoms into the heavier elements, and that secondary electrons were produced in the atmosphere by Compton scattering of gamma rays. But then, sailing from Java to the Netherlands in , Jacob Clay found evidence, [26] later confirmed in many experiments, of a variation of cosmic ray intensity with latitude, which indicated that the primary cosmic rays are deflected by the geomagnetic field and must therefore be charged particles, not photons. During the years from to , a wide variety of investigations confirmed that the primary cosmic rays are mostly protons, and the secondary radiation produced in the atmosphere is primarily electrons, photons and muons. In his report on the experiment, Rossi wrote " He concluded that high-energy primary cosmic-ray particles interact with air nuclei high in the atmosphere, initiating a cascade of secondary interactions that ultimately yield a shower of electrons, and photons that reach ground level. On 1 April , he took measurements at heights up to Bhabha derived an expression for the probability of scattering positrons by electrons, a process now known as Bhabha scattering. His classic paper, jointly with Walter Heitler , published in described how primary cosmic rays from space interact with the upper atmosphere to produce particles observed at the ground level. Bhabha and Heitler explained the cosmic ray shower formation by the cascade production of gamma rays and positive and negative electron pairs. A huge air shower experiment called the Auger Project is currently operated at a site on the pampas of Argentina by an international consortium of physicists, led by James Cronin , winner of the Nobel Prize in Physics from the University of Chicago , and Alan Watson of the University of Leeds. Their aim is to explore the properties and arrival directions of the very highest-energy primary cosmic rays. Since then, numerous satellite gamma-ray observatories have mapped the gamma-ray sky. The most recent is the Fermi Observatory, which has produced a map showing a narrow band of gamma ray intensity produced in discrete and diffuse sources in our galaxy, and numerous point-like extra-galactic sources distributed over the celestial sphere. Sources of cosmic rays[edit] Early speculation on the sources of cosmic rays included a proposal by Baade and Zwicky suggesting cosmic rays originated from supernovae. Babcock suggested that magnetic variable stars could be a source of cosmic rays. Later experiments have helped to identify the sources of cosmic rays with greater certainty. In , a paper presented at the International Cosmic Ray Conference ICRC by scientists at the Pierre Auger Observatory showed ultra-high energy cosmic rays UHECRs originating from a location in the sky very close to the radio galaxy Centaurus A , although the authors specifically stated that further investigation would be required to confirm Cen A as a source of cosmic rays. However, the term "cosmic ray" is often used to refer to only the GCR flux. Despite the nomenclature galactic, GCRs may originate within or outside the galaxy as discussed in the source section above. Primary cosmic particle collides with a molecule of atmosphere. Cosmic rays originate as primary cosmic rays, which are those originally produced in various astrophysical processes. Of these four, the latter three were first detected in cosmic rays. Primary cosmic rays[edit] Primary cosmic rays primarily originate from outside the Solar system and sometimes even the Milky Way. Cosmic rays made up of charged nuclei heavier than helium are called HZE ions. This abundance difference is a result of the way secondary cosmic rays are formed. Carbon and oxygen nuclei collide with interstellar matter to form lithium , beryllium and boron in a process termed cosmic ray spallation. Spallation is also responsible for the abundances of scandium , titanium , vanadium , and manganese ions in cosmic rays produced by collisions of iron and nickel nuclei with interstellar matter. These do not appear to be the products of large amounts of antimatter from the Big Bang, or indeed complex antimatter in the universe. Rather, they appear to consist of only these two elementary particles, newly made in energetic processes. Preliminary results from the presently operating Alpha Magnetic Spectrometer AMS on board the International Space Station show that positrons in the cosmic rays arrive with no directionality. These are actively being searched for. By not detecting any antihelium at all, the AMS established an upper limit of 1. These are produced by cosmic ray bombardment on its surface. The interaction produces a cascade of lighter particles, a so-called air shower secondary radiation that rains down, including x-rays , muons , protons, alpha particles , pions , electrons , and neutrons. Typical particles produced in such collisions are neutrons and charged mesons such as positive or negative pions and kaons. Some of these subsequently decay into muons , which are able to reach the surface of the Earth, and even penetrate for some distance into shallow mines. The muons can be easily detected by many types of particle detectors, such as cloud chambers , bubble chambers or scintillation detectors. The observation of a secondary shower of particles in multiple detectors at the same time is an indication that all of the particles came from that event. Cosmic rays impacting other planetary bodies in the Solar System are detected indirectly by observing high-energy gamma ray emissions by gamma-ray telescope. Cosmic-ray flux[edit] An overview of the space environment shows the relationship between the solar activity and galactic cosmic rays. However, the strength of the solar wind is not constant, and hence it has been observed that cosmic ray flux is correlated with solar activity. The following table of participial frequencies reach the planet [63] and are inferred from lower energy radiation reaching the ground.

Chapter 8 : What can particles tell us about the cosmos? | Prowl in virtual world

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Which is called high-energy neutrinos. It traverses space between people, plants, and animals. Has now giving scientists a new way to understand the Cosmos. What does the scientist say? As per the study, researchers on this Thursday gave a statement. In which they said that for the very first time they were able to locate a deep-space source of these ghostly particles. Which has a massive black hole right in the middle of it. Which is always spinning and black. Which according to a scientist is located at a distance of 3. How does this finding help? Well, this finding helped in understanding, or many may call in solving of a mystery. Which is dated all the way back to ? When these subatomic particles dashed through cosmos. So far, as per reports, it seems like these particles come from the most violent places in our universe. Stunning fact scientist said. As per scientist, we are swimming in these neutrinos. As according to the hundreds of billions of these passes through us every second. They said that one hundred billion neutrinos might pass through your thumbnail every second. However, they would never hit atoms of your thumbnail. Almost like a ghost, accurately why they are called ghost Particles. These particles according to the Scientist pass through you but never hit a single atom of your body. According to them, high energy neutrinos are made the same way as cosmic rays. The most energetic particle ever observed. However, different in key aspects from each other. According to the scientist, same as charged ghostly particles. Cosmos cannot be traced back to its source. The reason for that is the magnetic field in space which alters their trajectory. Which makes there pathway unpredictable and unable to be tracked all the way back to its origin or source. Both behave in the same way, which allows the scientist to understand one while observing another.

Chapter 9 : Virtual particles and the Nobel Prize â€“ Colin's Cosmos

Cosmic rays: particles from outer space Earth is subject to a constant bombardment of subatomic particles that can reach energies far higher than the largest machines In August , Austrian physicist Victor Hess made a historic balloon flight that opened a new window on matter in the universe.

May 23, What are the basic building blocks of the cosmos? Atoms, particles, mass energy? Quantum mechanics, forces, fields? Space and time â€” space-time? Tiny strings with many dimensions? A new candidate is "information," which some scientists claim is the foundation of reality. The late distinguished physicist John Archibald Wheeler characterized the idea as "It from bit" â€" "it" referring to all the stuff of the universe and "bit" meaning information. So, the question then becomes how to understand "information," a common term whose technical or scientific sense can be disruptive. Information has multiple meanings: Is information the ultimate constituent from which the cosmos is constructed? I started as a skeptic. Information as reality seems so outlandish, so trendy â€" a metaphor on steroids. Electrons can take only two distinguishable values: So, at rock bottom, Lloyd said, the universe consists of information; every elementary particle carries information. He sees the universe not like a computer as an explanatory metaphor; it really is a computer as scientific fact. As such, he claims that all changes in the universe are "computations. To Raphael Bousso, a string theorist at the University of California, Berkeley, information is not just a tool of measure â€" it is a primary constituent of what is happening in the world. Think of an ocean wave crashing on the shore, Lloyd said. While there is general agreement that information plays a role in all that happens in the cosmos, it is still a minority view that it is more fundamental than physics. Physicist Stephen Wolfram, founder of Mathematica and Wolfram Alpha, calls information "the most prominent thing of our times" and posits that "simple rulesâ€¦ generate what we see in nature. Extraordinary claims require extraordinary proof To Alan Guth, one of the founders of contemporary cosmology and a theoretical physicist and cosmologist at MIT, the notion of information as fundamental is not convincing â€" at least not yet. If information is primary and the universe is fundamentally a computer, then it should be at least theoretically feasible, in principle, to simulate whole worlds on future supercomputers. There is a further consequence. A simulated universe, fully formed like ours, would confirm reductionism â€" the idea that everything, including consciousness, could be reduced to physics, even to digital events. Could these theories that give information pride of place â€" however abstract and even bizarre â€" ever be tested? Even if the universe were a simulation, simulations are never perfect, so it might be possible to detect, at extreme levels of precision, fuzziness, glitches or even errors in the fine measurements of physics, such as drifts in core constants e. If information were fundamental, there should be ways of using information to improve the Standard Model of fundamental physics, which, although highly successful, has multiple free parameters so far without demonstrable, underlying coherence. Other possible tests of information as fundamental might include confirming the theory that the universe is like a hologram a 3D image projected from a 2D source and that space is not smooth and continuous but gridlike and discrete like information. So the question is a real one: In the grand chain of existence, is information bedrock? The views expressed are those of the author and do not necessarily reflect the views of the publisher. This version of the article was originally published on Space.