DOWNLOAD PDF RADIO WAVES FROM THE BIG BANG

Chapter 1 : 6 Things you may not know about the afterglow of the big bang | Latest Features | blog.quintoa

The Big Bang is a naturalistic story about the origin and development of the universe (e.g. a cosmology), beginning with a "singularity" when all mass, energy, and space was contained in a small point.

Electromagnetic energy travels as waves at the speed of light. Electromagnetic energy can be of varying wavelength distance between one wave crest to the next or conversely frequency how many wave crests pass per second. Electromagnetic energy ranges from radio waves at the longest wavelengths lowest frequencies to gamma rays at the shortest wavelengths highest frequencies. Red light is longer wavelength than violet light. Light coming from the sun appears white to us, but passing this light through a prism spreads the light into its constituent colors, the colors of the rainbow. The prism simply bends or refracts the light; short wavelengths are refracted by a greater amount than longer wavelengths. Astronomers during the nineteenth century discovered that when sunlight is passed through a prism dark lines at specific wavelengths appear on the rainbow of visible colors. The dark lines were determined to be caused by the absorption of certain wavelengths of light by atoms lying between the light source and the observer. This is because electrons orbiting the nucleus of an atom may absorb only specific wavelengths of light to supply just exactly the necessary energy to make the jump from a lower to a higher energy level. The electrons in atoms of a given element hydrogen for example may only make certain discrete energy jumps. There is a unique "fingerprint" of absorption lines for each element. Similarly, the spectrum of light from a heated, glowing gas of a given element gives off bright emission lines of the same wavelengths as the absorption lines for that element. Spectral analysis, identification of absorption and emission spectra, of sunlight, starlight, and light reflected from planet, asteroid, and comet surfaces can be used to identify elements found in the atmospheres and on the surfaces of those bodies. From spectral analysis we know that hydrogen H is by far the most abundant element in our solar system and in the universe. Helium He is a distant second. The characteristic spectral lines for hydrogen are shifted to lower frequencies toward the red end of the visible spectrum. This is similiar to the way the pitch of a horn on a passing train or car shifts to a lower pitch as the blaring horn moves quickly away. This is called a Doppler shift. When an observer is moving away from the transmitter of a wave light or sound the wave crests arrive at the observer more slowly than expected. Edwin Hubble interpreted the frequency shift of extra-galactic starlight to mean that distant galaxies are moving away from us. In fact, all of the observed galaxies are moving away from our own Milky Way Galaxy and from one another. And the farther away they are, the faster they are moving away from us. This is exactly like a gigantic explosion, or better yet, the expansion of a balloon, from exceedingly small size to the current size of the universe. All of the parts move outward away from the origin and away from one another as the balloon inflates and the skin stretches. This theoretical, great cosmic expansion was dubbed "The Big Bang. Based on the rate of expansion and the distances between galaxies, the Big Bang must have occurred some The Early Universe If the universe is expanding from such an event, what would the conditions have been like in the first moments of the universe when all of the matter and energy in the universe was concentrated in a very small point? Theoretical work shows that near the instant of creation, when the universe was seconds old, the pressures and temperatures were too great for normal matter to exist. Only quarks constituents of protons and neutrons and smaller particles including the nearly massless electrons and neutrinos existed. Protons and neutrons, which account for almost all of the mass of normal matter, formed as the universe rapidly expanded and the temperatures and pressures decreased. The Microwave Background Radiation By the time the universe was approximately , years old the temperature would have decreased to about Kelvin, finally cool enough for electrons to be captured by the hydrogen nuclei to form complete atoms. Prior to this time, the radiation that filled the universe was scattered by roaming electrons. After the electrons were captured by hydrogen and helium nuclei the universe became transparent. Radiation, including light, could now travel through the universe without being scattered. It was like the fog lifting to show a clear blue sky. The remnant scattered K radiation from , years after the Big Bang was predicted by the Big Bang Theory to be detectable in all directions, however at a longer wavelength lower temperature in the microwave range due to the expansion of the universe. In , Arno Penzias and Robert Wilson of Bell Labs accidentally discovered this background radiation as noise in a sensitive microwave receiver they were building in Holmdel, New Jersey. Contact was eventually made with Robert Dicke of Princeton University who was studying the early universe and whose student was trying to detect the background radiation. This discovery of an effect previously predicted by the Big Bang Theory is a very powerful support for the theory. The conditions in the rapidly expanding and cooling universe following the Big Bang were such that only simple matter was formed. The universe was filled with hydrogen H and small amounts of helium He. As the universe expanded, galaxies formed in areas of higher concentrations of H and He and stars formed within the galaxies in areas of highest concentrations of H and He.

Chapter 2 : Radio Astronomy - body, used, Earth, form, energy, methods, system, parts, waves

10 mysteries of the universe: What came before the big bang? Searing bursts of radio waves first spotted a decade ago could come from bouncing black holes - and that suggests a universe might.

Back in the s, Stephen Hawking described the COBE discovery of temperature variations in the afterglow of the big bang as "the most important discovery of the century, if not of all time. He is the senior project scientist for this mission. JWST will be the greatest telescope launched into space. Its infrared cameras will detect the faint light from the first stars and galaxies to form in the universe, over 13 billion years ago. The observatory is also fine-tuned to search for extra-solar planets, dark matter and dark energy. Back in the s, Stephen Hawking described the COBE discovery of temperature variations in the afterglow of the Big Bang as "the most important discovery of the century, if not of all time. Each of these experiments zoom in on the temperature variations that COBE discovered. COBE is like the face that launched a thousand ships. Balloon experiments are important because they are relatively inexpensive to fly and they can utilize the latest technology. Because they are airborne for a maximum of about 40 days per year, however, the amount of data they can collect is limited. The space-based WMAP mission has been in orbit since , collecting remarkable data that very well may lead to another Nobel Prize--or two or three. Microwaves are a low-energy form of radiation but higher in energy than radio waves. The cosmic microwave background blankets the universe and is responsible for a sizeable amount of static on your television set--well, before the days of cable. From studying the temperature variations--a millionth of a degree hotter here, a millionth of a degree cooler there--the WMAP team could deduce fundamental properties of the universe, including its age and shape, the ratio of matter to energy, the era when stars first ignited, and rate at which the universe continues to expand. The universe is The team found evidence to support the concept of inflation, which poses that the universe expanded many trillion times its size faster than a snap of the fingers at the outset of the Big Bang. The first set observations had focused on the temperature differences. In that crucial split second, changes occurred that allowed for the creation of stars and galaxies many million years later. WMAP has revealed that the first stars--the forebears of all subsequent generations of stars and of life itself--were fully formed remarkably early, only about million years after inflation. Polarization is affected by the environment through which the light passes, such as the polarized glare of sunlight reflecting off of a shiny object. With a richer temperature map and the new polarization map, WMAP data favor the simplest versions of inflation. Generically, inflation posits that, at the outset of the Big Bang, quantum fluctuations--short-lived bursts of energy at the subatomic level--were converted by the rapid inflationary expansion into fluctuations of matter that ultimately enabled stars and galaxies to form. The simplest versions of inflation predict that the largest-sized fluctuations will also be the strongest. The most recent results from WMAP favor this signature. So What Powered the Big Bang? To understand what powered the Big Bang, scientists need to probe this fleeting, explosive moment called inflation. There are two types of polarization signals from the microwave background, which scientists call E and B modes. The E mode points to the era of reionization, when the universe, after cooling down for millions of years, became warm again with new stars. These first stars ionized hydrogen atoms, liberating electrons from the protons, which scattered and polarized the big bang afterglow. The new WMAP data indicate that reionization, and thus star formation, occurred million years after the Big Bang, the most accurate assessment to date. B modes point way back to the inflationary epoch, the calling card of the Big Bang. Inflation attempts to resolve two problems with the Big Bang theory: The universe is flat and uniform. Sure, any space will reach equilibrium given enough time. But the universe was at a uniform temperature at age , years. Energy would have had to move over times the speed of light to make things that uniform that early. Inflation provides the speed. Inflation also expands the universe quickly enough to flatten out any wrinkles in spacetime that could have been created by gravity or would have caused the nascent universe to implode. But the temperature map and the E-mode polarization map can make specific statements about inflation, such as an upper limit on its energy. Hearing the Big Bang Itself The European Space Agency plans to launch a mission called Planck in that will study microwave background polarization. The race is on. One route could be a highly advanced polarization detector. But other ideas might emerge as well. Theory predicts that we can directly detect the Big Bang, the very moment of the creation of space and time as we know it. This would be a remarkable achievement for humankind, and with dedication this visionary goal can be attain within two decades. No ordinary telescope will do. Light, or electromagnetic radiation, can only allow us to view the moments after the Big Bang. But the Big Bang made a rumble, a vibration in the fabric of space and time called a gravitational wave that is still ringing today. The ground-based LIGO experiment , now in operation, and the space-based LISA mission , proposed for launch next decade, hope to detect gravitational radiation from objects in the universe, such as black holes. There is overwhelming indirect evidence for their existence, though. The "Big Bang observer" would build upon LISA; this would be an ultra-sensitive detector tuned to the low, faint frequency of that primordial Big Bang gravitational wave. This is the Holy Grail of cosmology, to witness the birth of the universe. So as you can see, COBE was just the beginning of great science to come.

Chapter 3 : The Sound of the Big Bang

The 'afterglow of creation' - commonly known as the cosmic background radiation - is the left-over heat from the fireball of the big bang in which the Universe was born billion years ago.

Gravitational waves are ripples in the space-time continuum, which was envisaged by Albert Einstein in his general theory of relativity. Gravitational waves are ripples that carry energy across the universe. They were predicted to exist by Albert Einstein in as a consequence of his General Theory of Relativity. Although there is strong circumstantial evidence for their existence, gravitational waves have not been directly detected before. This is because they are minuscule â€” a million times smaller than an atom. These carry vital information about how the universe began. What is general relativity? In , Albert Einstein discovered a mathematical way to explain gravity. He called it his general theory of relativity. It relied on a set of coordinates that described space and time together, known as the space-time continuum. Matter and energy warp the space-time continuum like heavy weight on a mattress. The warping creates the force of gravity. Gravitational waves are ripples in the space-time continuum instead of an ordinary mattress, think of a waterbed. General relativity tells us how gravity affects time, which must be taken into account by your satnav to tell you accurately where you are. What is the significance of this discovery? If scientists at Harvard University have detected gravitational waves , it is significant for two reasons. First, this opens up a whole new way of studying the Universe, allowing scientists to infer the processes at work that produced the waves. Second, it proves a hypothesis called inflation. This can be used to give us information about the origin of the universe, known as the big bang. How can gravitational waves be detected? A telescope at the south pole, called Bicep Background Imaging of cosmic Extragalactic Polarisation , has been searching for evidence of gravitational waves by detecting a subtle property of the cosmic microwave background radiation. This radiation was produced in the big bang. It was originally discovered by American scientists in using a radio telescope and has been called the "echo" of the big bang. Bicep has measured the large-scale polarisation of this microwave radiation. Only primordial gravitational waves can imprint such a pattern, and only then if they have been amplified by inflation. He called it "the day without yesterday" because it was the moment when time and space began. The distribution of matter across space is too uniform to have come from the big bang as originally conceived. So in the s, cosmologists postulated a sudden enlargement of the universe, called inflation, that occurred in the first minuscule fraction of a second after the big bang. But confirming the idea has proved difficult. Only inflation can amplify the primordial gravitational wave signal enough to make it detectable. If primordial gravitational waves have been seen, it means that inflation must have taken place. Do cosmologists just pack up and go home? Now the work really begins. Einstein knew that general relativity did not mesh with another theory of physics called quantum mechanics. Whereas general relativity talks about gravity and the universe as a whole, quantum mechanics talks about the small scale of particles and the other forces of nature, the strong and weak nuclear forces, and electromagnetism. The primordial gravitational waves were generated when gravity and the universe were working on the same scale as particles and the other forces of nature. This detection and the subsequent analysis will hopefully tell us how. If it does, this could lead to what physics wistfully call "the theory of everything".

Chapter 4 : What are gravitational waves? | Science | The Guardian

Radio waves from the big bang. This sound is 13 billion years old. How did they get the sound? The sound has been travelling around the universe and reached planets and NASA picked up the radio waves.

The cosmic microwave background radiation is an emission of uniform, black body thermal energy coming from all parts of the sky. The radiation is isotropic to roughly one part in , The CMB dipole as well as aberration at higher multipoles have been measured, consistent with galactic motion. The remaining irregularities were caused by quantum fluctuations in the inflaton field that caused the inflation event. As the universe expanded , adiabatic cooling caused the energy density of the plasma to decrease until it became favorable for electrons to combine with protons , forming hydrogen atoms. The intensity of the radiation also corresponds to black-body radiation at 2. According to the Big Bang model, the radiation from the sky we measure today comes from a spherical surface called the surface of last scattering. This represents the set of locations in space at which the decoupling event is estimated to have occurred [14] and at a point in time such that the photons from that distance have just reached observers. The CMB spectrum has become the most precisely measured black body spectrum in nature. Discovery of cosmic microwave background radiation The cosmic microwave background was first predicted in by Ralph Alpher and Robert Herman. This high estimate was due to a mis-estimate of the Hubble constant by Alfred Behr, which could not be replicated and was later abandoned for the earlier estimate. Although there were several previous estimates of the temperature of space, these suffered from two flaws. First, they were measurements of the effective temperature of space and did not suggest that space was filled with a thermal Planck spectrum. Next, they depend on our being at a special spot at the edge of the Milky Way galaxy and they did not suggest the radiation is isotropic. The estimates would yield very different predictions if Earth happened to be located elsewhere in the universe. The mainstream astronomical community, however, was not intrigued at the time by cosmology. The first published recognition of the CMB radiation as a detectable phenomenon appeared in a brief paper by Soviet astrophysicists A. Doroshkevich and Igor Novikov , in the spring of Penzias and Wilson received the Nobel Prize in Physics for their discovery. This was largely because new measurements at a range of frequencies showed that the spectrum was a thermal, black body spectrum, a result that the steady state model was unable to reproduce. RELIKT-1 , a Soviet cosmic microwave background anisotropy experiment on board the Prognoz 9 satellite launched 1 July gave upper limits on the large-scale anisotropy. Inspired by the COBE results, a series of ground and balloon-based experiments measured cosmic microwave background anisotropies on smaller angular scales over the next decade. The primary goal of these experiments was to measure the scale of the first acoustic peak, which COBE did not have sufficient resolution to resolve. This peak corresponds to large scale density variations in the early universe that are created by gravitational instabilities, resulting in acoustical oscillations in the plasma. Relationship to the Big Bang[edit].

Chapter 5 : Cosmic microwave background - Wikipedia

The good agreement between mathematical models of the Big Bang and the observed microwave spectrum provides one of the three main pillars that make up the theoretical foundations of the Big Bang.

Radio Astronomy Radio astronomy Matter in the universe emits radiation energy from all parts of the electromagnetic spectrum, the range of wavelengths produced by the interaction of electricity and magnetism. The electromagnetic spectrum includes light waves, radio waves, infrared radiation, ultraviolet radiation, X rays, and gamma rays. Radio astronomy is the study of celestial objects by means of the radio waves they emit. Radio waves are the longest form of electromagnetic radiation. Some of these waves measure up to 6 miles more than 9 kilometers from peak to peak. Objects that appear very dim or are invisible to our eye may have very strong radio waves. Words to Know Big bang theory: Theory that explains the beginning of the universe as a tremendous explosion from a single point that occurred 12 to 15 billion years ago. Radiation that transmits energy through the interaction of electricity and magnetism. Short-wavelength, high-energy radiation formed either by the decay of radioactive elements or by nuclear reactions. Electromagnetic radiation of a wavelength shorter than radio waves but longer than visible light that takes the form of heat. Rapidly spinning, blinking neutron stars. Extremely bright, starlike sources of radio waves that are the oldest known objects in the universe. Longest form of electromagnetic radiation, measuring up to 6 miles from peak to peak. Electromagnetic radiation energy of a wavelength just shorter than the violet shortest wavelength end of the visible light spectrum. The distance between two peaks in any wave. Electromagnetic radiation of a wavelength just shorter than ultraviolet radiation but longer than gamma rays that can penetrate solids and produce an electrical charge in gases. In some respects, radio waves are an even better tool for astronomical observation than light waves. Light waves from distant objects are also invisible during daylight because light from the Sun is so bright that the less intense light waves from more distant objects cannot be seen. Radio waves, however, can be detected as easily during the day as they can at night. Origins of radio astronomy No one individual can be given complete credit for the development of radio astronomy. In the early s, Jansky was working on the problem of noise sources that might interfere with the transmission of short-wave radio signals. During his research, Jansky discovered that his instruments picked up static every day at about the same time and in about the same part of the sky. It was later discovered that the source of this static was the center of the Milky Way galaxy. Grote Reber, an amateur radio enthusiast in Wheaton, Illinois, took it upon himself to begin examining the radio signals from space. He mounted a receiver above the dish. Reproduced by permission of JLM Visuals. He worked virtually alone until the end of World War II â€”45 , when scientists began adapting radar tracking devices for use as radio telescopes. What radio astronomy has revealed Scientists have found that radio signals come from everywhere. Our knowledge of nearly every object in the cosmos has been improved by the use of radio telescopes. Radio astronomy has amassed an incredible amount of information, much of it surprising and unexpected. The eta Carinae nebula as seen by visible light bottom , X rays top left , and radio waves right. Each shows a different image of the nebula. Reproduced by permission of National Aeronautics and Space Administration. In , astrophysicists detected radio bursts coming from Jupiter. Next to the Sun, this planet is the strongest source of radio waves in the solar system. Around this time, Dutch astronomer Jan Oort used a radio telescope to map the spiral structure of the Milky Way galaxy. In , several small but intense radio sources were discovered that did not fit into any previously known classification. They were called quasi-stellar radio sources. Further investigation revealed them to be quasars, the most distant and therefore the oldest celestial objects known. And in the late s, English astronomers Antony Hewish and Jocelyn Bell Burnell detected the first pulsar neutron star , a strong radio source in the core of the Crab Nebula. Evidence of the big bang. In , radio astronomers found very compelling evidence in support of the big bang theory of how the universe began. Americans Arno Penzias and Robert Wilson discovered a constant background noise that seemed to come from every direction in the sky. This corresponded to the predicted temperature to which radiation left over from the formation of the universe 12 to 15 billion years ago would have cooled by the present. Today astronomers use radio astronomy and other sophisticated methods including gamma ray, infrared, and X-ray astronomy to examine the cosmos. The largest single radio telescope dish presently in operation, with a diameter of 1, feet meters , is in Arecibo, Puerto Rico. Terence Murphy Sep 10, 7: Absolute zero is Celsius. The CMB temperature is then slightly below.

Chapter 6 : NASA - Background on the Background Explorer and the Science of John Mather

Radio astronomy is the study of celestial objects by means of the radio waves they emit. Radio waves are the longest form of electromagnetic radiation. Some of these waves measure up to 6 miles (more than 9 kilometers) from peak to peak.

Share via Print Proof of gravitational waves created by cosmic inflation is shown here in this image of the cosmic microwave background radiation collected by the BICEP2 experiment at the South Pole. The proof comes in the form of a signature called B-mode polarization, a curling of the orientation, or polarization, of the light, denoted by the black lines on the image. The color indicates small temperature fluctuations in the cosmic microwave background that correspond to density fluctuations in the early universe. BICEP2 Collaboration Advertisement Physicists have found a long-predicted twist in light from the big bang that represents the first image of ripples in the universe called gravitational waves, researchers announced today. The finding is direct proof of the theory of inflation, the idea that the universe expanded extremely quickly in the first fraction of a nanosecond after it was born. To me this is as Nobel Prizeâ€"worthy as it gets. This pattern, basically a curling in the polarization, or orientation, of the light, can be created only by gravitational waves produced by inflation. Nevertheless, the result has won praise from many leaders in the field. In fact, the researchers were so startled to see such a blaring signal in the data that they held off on publishing it for more than a year, looking for all possible alternative explanations for the pattern they found. The cosmic microwave background is a faint glow that pervades the entire sky, dating back to just , years after the big bang. Before then the baby universe was too hot and dense for light to travel far without bumping into matter. When it cooled to the point that neutral atoms could form, light was freed to fly through space unimpeded, and it became the CMB. This glow was discovered accidentally by Arno Penzias and Robert Wilson, who initially mistook it for interference caused by pigeon droppings on their antenna. Eventually, the scientists realized they had discovered an imprint from the primordial universe, a finding that won them the Nobel Prize in Physics. The instrument collected data between January and December at the Amundsenâ€"Scott South Pole Station, where the cold, dry air offers especially stable viewing conditions. Another experiment there, the South Pole Telescope, reported finding B-mode polarization last year , although the signal it saw was at a different angular scale across the sky and was clearly due to the known process of gravitational lensing a warping of light caused by massive objects of the CMB by large galaxies, rather than the primordial gravitational waves seen here. Given that the BICEP2 team saw such a clear signal, these searches should easily confirm the results if they are real. The BICEP2 researchers have reported a surprisingly large number for r, the ratio of the gravitational wave fluctuations in the CMB to the fluctuations caused by perturbations in the density of matter. This value was previously estimated to be less than 0. In fact, the models that looked like they were ruled out last week are now the models that are favored this week. The timing of inflation, in turn, tells physicists about the energy scale of the universe when inflation was going on. The finding bolsters the idea of grand unification and rules out a number of inflation models that do not feature such an energy scale. These new fields, in turn, would indicate that other, heavier Higgs boson particles also exist, although with masses so high they would be impossible to create in any traditional particle accelerator.

Chapter 7 : Cosmic noise - Wikipedia

The most widely accepted explanation is the big bang theory. Learn about the explosion that started it all and how the universe grew from the size of an atom to encompass everything in existence.

Chapter 8 : RADIO WAVES and PHOTONS? | Yahoo Answers

That transformed the hydrogen gas, making it soak up background radiation left over from the Big Bang â€" and the transformation caused a telltale dip in the spectrum of radio waves that reached.

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Chapter 9 : Cosmic dawn: astronomers detect signals from first stars in the universe | Science | The Guard

The Big Bang is the ENTIRE universe, and early in its history it was hot and dense absolutely everywhere. There was no center of gravity to struggle outward from, since everywhere in the universe contained the same amount of density, just like today.