some UNANSWERED QUESTIONS IN PHYSICS



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PHYSICS

• Encyclopedia Brittanica

physics (Greek: φύσις (phúsis), "nature" and φυσικῆ (phusiké), "knowledge of nature")

the science that deals with the structure of matter and the interactions between the fundamental constituents of observable universe

outline

- scientific process, XX-century physics, some details and a summary of what we know today from a point of view of particle physicist - the Standard Model
- beyond Standard Model, how to study?
- some new results, puzzles and what they may mean

Mathematics N Physics



FINDING DISCREPANCIES LEADS TO DEVELOPMENT OF NEW THEORIES

Experiment (observation) can only invalidate a theory, one can **never** prove it

Experiments should be repeatable

Mathematics N Physics

• "Scientific method" in shortened version:



• But, some say (Dirac, Einstein, ancient Greek philosophers...)

This is usually called mathematical physics, or "really theoretical" physics

(Is mathematics just the language of physics, or does it exist on its own? Were negative numbers invented or discovered?)

some UNANSWERED QUESTIONS IN PHYSICS

- · SPACE
- . TIME
- MATTER
- FORCES

- end of XIXth century absolute R³ absolute R^{1*}
- molecules, atoms
- contact forces, gravity, electricity and magnetism

 In 1869 Mendeleyev published the periodic table of chemical elements (made of distinct type of atoms), there was a peculiar regularity, atoms separated by 8 positions had similar chemical properties. ARE ATOMS ELEMENTARY?

1	÷.	Hydrogen Semiconductors																
	Hydrogen				Atomic N	umber	6		(also known as motafieidd)									Group 18
	Group 1	Symbol C Alla Alla Geoup 2 Name Carbon							Metals Alkali n Alkalino Tisansiti Other n	Metals Alkaline-carh metals Lansition metals Dther metals Dther metals Croup 13 Group 14 Group 15 Group 16 Group 17								
2	3 Li Lithium 6.941	4 Average Atomic Mass 12.0107 Nonenetals 5 6 7 8 9 Beryllum 9.012 182 Halogens Notice gates Boron Carbon Nitrogen Oxygen Fluorine Fluorine 12.0107 14.0067 15.9994 Fluorine 15.9994<										9 F Fluorine 18.998 4032	10 Ne Neon 20.1797					
3	11 Na Sodium 22.989 769 28	12 Mg Magnesium 24.3050	12 13 14 15 18 17 11 Mg Isgression 243550 Group 3 Group 4 Group 5 Group 6 Group 7 Group 8 Group 9 Group 10 Group 11 Group 11 Group 12 25/961 Solition 25/97/37/82 Sulture 32/97/37/82 Sultu										18 Ar Argon 39.948					
4	19 K Potassium 30.0983	20 Ca Calcium 40.078	21 Sc Scandlum 44,955 912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938.045	26 Fe Iron 55.845	27 Co Cobalt 58.933 195	28 Ni Nickel 58.6934	29 Cu Copper 63.548	30 Zn Zine 65.409	31 Ga Gallum 69.723	Germanium 72.84	33 As Arsenic 74.921.60	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.82	39 Y Yttrium 88.905.85	40 Zr Zirconium 91.224	41 Nb Niablum 92.906 38	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.905.50	46 Pd Palladium 108.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	40 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Telturium 127.60	53 lodine 125.904 47	54 Xe Xenon 131,293
6	55 Cs Cesium 132.905 4519	58 Ba Barlum 137.327	57 La Lanthanum 138.905 47	72 Hf Hatnium 178.49	73 Ta Tantalum 180.947 88	74 W Tungaten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Hidium 192.217	78 Pt Platinum 195.084	79 Au Gold 198.985 589	80 Hg Mercury 200.59	81 TI Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.980.40	84 Po Polonium (209)	Astatine (210)	86 Rn Radon (222)
7	Fr	Ra	Ac	104 Rf	105 Db	Sg	Bh	Hs	Mt	DS	Rg	Uub*		Uuq*		Uuh*		
	(223)	(228)	(227)	(261)	(282)	(266)	(284)	(277)	(268)	(271)	(272)	(285)		(289)		(292)		

Periodic Table of the Elements

 The systematic names and symbols for elements greater than 111 will be used until the approval of trivial names by the IUPAC.

Periodic Table of the Elements

The discoveries of elements with atomic numbers 112, 114, and 116 have been reported but not fully confirmed.

	58 Ce Cerium 140.116	59 Pr Praseodymium 140.907 65	80 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	Eu Eu Europium 151.964	64 Gd Gadolinium 157,25	65 Tb Terbium 158.925 35	Dy Dysprosium 162.500	67 Ho Hoimium 164,930 32	68 Er Erbium 167.259	69 Tm Thulium 168,934 21	70 Yb Ytterbium 173.04	21 Lu Lutetium 174.967
	Th	Pa	Ű	Np	Pu	Am	Cm	⁹⁷ Bk	° ⁸ Cf	Es	Fm	Md	102 No	Lr
3	132.038.06	231.035 88	238.028 91	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	Mendelevium (258)	(259)	(262)

The atomic masses listed in this table reflect the precision of current measurements. (Each value listed in parentheses is the mass number of that radioactive element's most stable or most common isotope.)

Molecules and atoms

- Through some very clever measurements XIX century scientists measured the size of molecules to be of the order of
 1/10 000 000 000 m = 10⁻¹⁰ m.
- It is as small a fraction of I m as single second is of a 320 year period !!!
- Atoms are little smaller than molecules, but not a lot.

Molecules and atoms

- I A(ngstrom) = I 0⁻¹⁰ m
- "Picture" of a monoatomic layer of silicon atoms (from Franz Giessibl)



Is Physics finished?

- Such opinions were voiced not unfrequently by the end of XIXth century. All matter was understood to be composed of different atoms
- one could *in principle*, given the knowledge of initial conditions and the Physics Laws (Newton's three laws of mechanics, Newton's law of gravity and Maxwell's laws of electromagnetism) calculate positions of particles in a system COMPLETELY DETERMINISTICALLY at any moment of time
- maybe there were too many of chemical elements for atoms to be really elementary, black-body radiation was unexplained and it was strange that Lorentz transformations were needed to keep Maxwell equations invariant

Breakthrough (experiment)

- In 1895 Thomson discovered electrons, negative electric charge, mass almost 2000 times smaller than that of hydrogen atom, the lightest of all elements
- In 1896 Becquerel discovered radioactivity, Marie Curie-Sklodowska identified several new radioactive elements
- scientists discovered that with the emission of radiation chemical elements MAY transform into a different chemical element

Breakthrough(experiment)

- In 1910 Thomson and Rutherford identified a positive particle, a proton, mass was almost equal to that of a hydrogen atom.
- Rutherford discovered that a tiny, hard core exist inside of an atom. In his model of ATOM, a positively charged nucleus is surrounded by a cloud of electrons, making atoms neutral.
- The nucleus is only 1/100 000 of the atom size (if atom was the size of a football field, a nucleus would be 1 mm), or ~10⁻¹⁵ m.
- THE SPACE INSIDE ATOMS IS VERY EMPTY.

What is matter made of?

- Molecules are formed when the electron clouds of the atoms overlap and form stable configurations
- The dimensions of atoms, or of molecules, are really of the dimensions of the outside boundaries of their electron clouds
- We are really made of mainly EMPTY space, filled with electron clouds, with very tiny nuclei at their centers, almost all mass is in the nuclei

Classical atom (Helium)



NOT TO SCALE!!

Breakthrough(theory)

- In 1900 Planck quantum of energy to explain the black-body radiation
- In 1905 Einstein explained the photo-electric effect using the same idea
- To explain atomic emission and absorption spectra of atoms a new theory was developed - QUANTUM MECHANICS - by Schrodinger and Heisenberg in 1926
- PHYSICS ON ATOMIC SCALE IS GOVERNED BY QUANTUM MECHANICS - no longer completely deterministic as in classical physics

Breakthrough(theory)

- Special theory of relativity (SR) developed by Einstein in 1905
 - Time and space no longer absolute
- Minkowski interpretation of SR as a consequence of time and space being in reality an unseparable space-time ("world") 1907
- General Theory of relativity Einstein 1907-1915 a new theory of gravity

Breakthrough(experiment)

- For about 20 years in the beginning of XXth century scientists thought that electron and proton are true building blocks of matter
- In 1928 Dirac, *as a result of purely mathematical studies*, postulated existence of an anti-particle to the electron, a positron; Rutherford postulated existence of a neutron
- In 1932 a positron was discovered by Anderson, and a neutron by Chadwick
- In 1931 a neutrino, neutral particle with zero (or almost zero) mass was postulated by Pauli; antiprotons postulated in 1930 were discovered in 1955
- In 1960, the number of "elementary particles" was about 70, and growing; it became clear that they cannot be elementary, very much as it was the case with chemical elements less than a 100 years earlier

What is matter made of?

 In 1963, Zweig and Gell-Mann introduced, again as a result of mathematical studies seeking the simplest picture, a theory of quarks which are the new building blocks of all hadrons and mesons - a new, deeper, level of elementary particles

symmetries <=> conservation laws THE FOUNDATION OF XXth PARTICLE PHYSICS

- Emmy Noether (mathematician) discovered the connection between symmetries and conservation laws while working with David Hilbert and Felix Klein in Gottingen
- In 1918 she proved two theorems, for finite continuous groups and infinite continuous groups which are the foundations of the modern (XXth century) physics. The theorems are collectively known as "Noether's theorem"
- Informally, Noether's theorem says:

differentiable symmetry generated by local actions <=> conserved current or there is one-to-one correspondence between symmetries and conservation laws

symmetry <=> conservation law

symmetries <=> conservation laws

- examples:
 - energy is conserved if and only if (iff) the physical laws are invariant under time translations (if the form of physics laws do not depend on time)
 - linear momentum is conserved only iff the physical laws are invariant under space translations (if the form of physics laws do not depend on the position)
 - angular momentum is conserved iff the physical laws are invariant under rotations (if the physics laws do not depend on orientation; if only true about a particular direction <=> only the component of angular momentum in that direction is conserved)

symmetries <=> conservation laws

- Modern particle physics is based entirely on the idea of underlying internal symmetries:
 - The electro-weak sector is based upon the (internal) symmetries which the electromagnetic and weak interactions obey U(I) and SU(2)
 - The strong sector of the Standard Model (SM), quantum chromodynamics (QCD) is based on the (internal) SU(3) symmetries observed in hadron spectroscopy
 - Spontaneous symmetry breaking has been proposed to explain massive weak bosons (Z, W) and the massless photon. The prediction of the W and Z bosons came from symmetry arguments and the discovery of these particles at CERN was one of the greatest successes of modern particle physics

WHAT DO WE KNOW TODAY?? a particle physicist view - STANDARD MODEL

• SPACETIME

not separate 3-dim space and 1-dim time, but inseparable FLAT 4-dim manifold: Minkowski spacetime (he called it "world")

• MATTER

leptons+quarks (6 of each + their antiparticles, 6 of each)

• INTERACTIONS strong (8 gluons, massless quanta) electromagnetic (massless 🐼) weak (heavy W⁺, W⁻, Z quanta) gravity UNEXPLAINED !!!

WHAT DO WE KNOW ?? a particle physicist view - STANDARD MODEL



STANDARD MODEL

• Current understanding of elementary particles and their strong and electro-weak interactions is given by Standard Model, a gauge theory based on the following internal symmetries:

$SU(3)_{c} \boxtimes SU(2)_{I} \boxtimes U(I)_{Y}$

- The SU(3) is an unbroken symmetry, it gives QCD, a quantum theory of strong interactions, whose carriers (gluons) are massless
- SU(2) U(1) (quantum theory of electroweak interactions) is spontaneously broken by the Higgs mechanism; which gives mass to electroweak bosons (W⁺, W⁻, Z^o and a massless photon)
- In the Minimal Standard Model, the Higgs sector is the simplest possible: contains two complex Higgs fields, which after giving masses to W,Z give leaves a neutral scalar Higgs particle which should be observed - the ONLY particle not yet discovered in MSM

STANDARD MODEL

- Matter is build of fermions quarks and leptons, three families of each, with corresponding antiparticles; quarks come in three colors
- Bosons are carriers of interactions: 8 massless gluons (strong), 3 heavy weak bosons W,Z (weak) and 1 massless photon (electromagnetic)
- A massive scalar Higgs field permeates the Universe and is (in some way) responsible for masses of other particles (SHOULD BE DISCOVERED !!)



~28 parameters NOT predicted by SM:

- masses of 6 quarks
- masses of 6 leptons
- coupling constants of SU(3), SU(2) and U(1)
- Higgs mass and vacuum expectation value
- Cabibbo-Kobayashi-Maskawa matrix angles and complex phase
- Maki-Nakagawa-Sakata matrix angles and complex phase
- QCD phase 🕅

ALL MUST BE MEASURED !!!

GRAVITY UNEXPLAINED !!!

STANDARD MODEL- questions??

- why so many free parameters: all masses, all couplings, all mixing angles and CP-violating phases
- why 6 quarks and 6 leptons is there an additional symmetry?
- why quarks and and leptons come in three pairs (generations)?
- why is CP not an exact symmetry (or why are laws of physics not symmetrical between matter and antimatter?) perhaps related why is our Universe matter-dominated?
- are quarks and leptons elementary or do they have structure at scale smaller than we can see (<10⁻¹⁸ m)?

Muon and electron look identical, except for their masses, could muon be an "excitation" of what constitutes an electron?? (in which case leptons will not be elementary !!)

STANDARD MODEL- questions??

- neutrinos Dirac or Majorana ? Do all have very small but nonzero masses?
- is the proton stable?
- QCD confinement of quarks and gluons was never proven; if we live in low temperatures where confinement works is there a phase transition at higher temperatures where quarks become free?
- what is the nature of spontaneous symmetry breaking of electroweak theory?
- do strong and electroweak interactions become one at very high energies ?
- what is the origin of MASS?

STANDARD MODEL- beyond?

- Many competing theories and models NEED NEW DATA !
- SUPERSYMMETRY
- Other grand-unification models
- Strings/Superstrings/membranes
 - Very attractive as they can explain gravity and other interactions (open and closed strings)
 - However, they are only consistent in 26 dimensions, or in 10 dimensions if supersymmetry is also assumed
 - Since our spacetime seems 4-dimensional, the remaining 6 or 22 dimensions are either very small or very large and we simply are not aware of them !!!
 - Gravitation will be different at small distances (where it is very hard to measure) if there were additional small dimensions

SUPERSYMMETRY





SUPERSYMMETRY (a space-time symmetry) - postulates existence of bosonic matter particles, and fermionic carriers of interactions, not exact, since supersymmetric partners must be heavy as they have not been observed; for every known particle there should be a supersymmetric partner

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HOW TO STUDY THOSE QUESTIONS?

• ACCELERATOR EXPERIMENTS - collide particles (protons, antiprotons, electrons, positrons) as high energies as possible, study particles that emerge from collisions; deviations from SM maybe "new physics"

• Precision low energy experiments - compare with precise calculations where tiny deviations from predictions based on SM may point to "new physics"

• astrophysics + cosmology: look at the Universe, the farther out one looks, the more back in time one sees, one can extrapolate from very early Universe to present assuming known physics laws, and compare the predicted sky with reality = ASSUMES VALIDITY OF KNOWN PHYSICS LAWS AT ALL TIMES, also violates the scientific principle as ONE CANNOT REPEAT THE EXPERIMENT !! (our Universe is the only one we know!)

TEVATRON proton-antoproton collider 2 TeV cms energy

FERMILAB'S ACCELERATOR CHAIN

Family ID-405





Fermi National Accelerator Laboratory

Some Unanswered Questions, Tufts, April 20, 2007

RUN-II AT TEVATRON/ CDF



European Centre for Particle Physics/ CERN/ Large Hadron Collider 14 TeV cms energy



European Centre for Particle Physics/ CERN/ Large Hadron Collider 14 TeV cms energy



European Centre for Particle Physics/ CERN/ Large Hadron Collider




European Centre for Particle Physics/ CERN/ Large Hadron Collider/ ATLAS detector



LHC:NEW DATA IN 2007-2008!!!



some UNANSWERED QUESTIONS IN PHYSICS

• SPACE how many dimensions?

· locally our space looks like 3-dim Euclidean space, flat

• BUT (for example) the supersymmetric string theories (fashionable in the last 20 or so years), which describe gravity and other interactions and matter particles, are only valid in 10 dimensions (dimensions other than 3 that we see can be very small or very large) or in 26 dimensions if no supersymmetry

• DO WE LIVE IN MORE THAN 3+1 DIMENSIONAL UNIVERSE?

WHAT IS THE TOPOLOGY OF OUR UNIVERSE?



some UNANSWERED QUESTIONS IN PHYSICS

• SPACE finite or infinite? bounded or unbounded? how many dimensions?

examples in 1-dimensional space:



some of the UNANSWERED QUESTIONS IN PHYSICS

• SPACE how many dimensions?



a 2-dim sheet rolled and glued results in a cylinder, if one let the radius R 🔣 0, result will look like a thread, a 1-dim object

some of the UNANSWERED QUESTIONS IN PHYSICS

• SPACE how many dimensions?



spherical geometry >0



flat geometry =0



parabolic geometry [¥]<0



Connection between physics on small and large scales

• In 1929 Hubble discovered that the Universe is expanding, the further away the galaxies are from us the faster they move away from us

• If one extrapolates back in time, assuming that the physics laws we know apply during the entire extrapolation, one has to conclude that the energy density (or temperature) and matter density were much higher in the past

• We cannot extrapolate back beyond Planck's length (10⁻³³ m) or Planck's time (10⁻⁴³ s) as quantum gravity effects must be important and we don't know how to calculate them, but one can use SM of particle physics wherever it is possible to evolve the early universe to NOW - Standard Model of Cosmology CDM

• we can then compare the results with OUR UNIVERSE, there is one problem - we only know one universe, the "experiment" cannot be repeated

Connection between physics on small and large scales



Big Bang and CMB

- The Universe is filled currently with radiation of a black-body at a temperature of 2.726K, whose spectrum peaks at about 300GHz. This radiation is known as the *Cosmic Microwave Background* (CMB).
- Penzias and Wilson 1964 noticed isotropic excess noise in radio emissions from the Milky Way
- Dicke, Peebles, Roll and Wilkinson gave the CMB interpretation
- Both papers published side by side in 1965



The CMB Spectrum

- successes of the big bang model are:
 - It predicts a perfect black body spectrum in CMB.
 - It predicts the details of the anisotropies in CMB.
- COBE measured and confirmed black body spectrum. It also discovered temperature variations at the level of 1 part in 100,000.



COBE AND WMAP

The temperature of the CMB is the same in all directions with no variations (the CMB sky is isotropic) at the level of 1/100



If one turns up the contrast to see fluctuations at the level of *I part in 1000*, the COBE sky map looks like this - a pure dipole pattern.

Why dipole? It is because we ourselves are moving with respect to the CMB and its temperature appears redshifted or blueshifted by the Doppler effect. The inference is that our entire local group of galaxies is moving in the direction of Virgo at about 600 km/s.



Here is the COBE map if we remove the dipole and turn up the contrast on the previous map to the level of 1 part in 100,000.

The map above has the equator placed according to where the galactic disk of the Milky way appears on the sky. We see <u>contamination from</u> <u>our own galaxy along the equator</u>. Marked red thing is the emission from the Milky Way (our galaxy)

WMAP - CMB Anisotropy after COBE

- COBE's best resolution was about 7 degrees. The more advanced Wilkinson Microwave Anisotropy Probe (WMAP) has precisely measured these anisotropies over the whole sky down to angular scales of 0.2 degrees. These can be used to estimate the parameters of the standard CDM model of cosmology.
- Some information, like the geometry of the Universe, can be obtained straightforwardly from the cosmic microwave background as well.

Results from WMAP/ fluctuations in cosmic microwave radiation



how to study the "noise"

- What we want to do is determine its spectral properties: Does it have any features?
- when we speak of the spectrum of the noise, we mean <u>the</u> <u>angular coherence of the temperature fluctuations</u>
- Mathematically, the multipole moments arise from a spherical harmonic decomposition of the fluctuations in angle.



 I=10 means that there are ten cycles in the fluctuation around the whole sky, while I=100 means that there are 100 cycles around the sky. Therefore the relation between I and the point to point angular difference q is I ~ 180°/q.

The image above shows an all-sky map with only I=2 power on the left, and another map with only I=16 power on the right.

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Results from WMAP

angular correlations in fluctuations of cosmic microwave radiation



Results from WMAP

CAVEAT: INVOLVES EXTRAPOLATION FROM ALMOST THE VERY BEGINNING TO NOW ASSUMING THAT ALL WE KNOW ABOUT PHYSICS LAWS AND CONSTANTS WAS TRUE AND VALID AT ALL TIMES !!!

- Expansion rate $H_o = 71 \pm 4 \text{ km/s/Mpc}$
- Dark energy $\Omega_{\Lambda} = 73 \pm 4\%$
- Dark matter $\Omega_m = 23 \pm 4\%$
- Ordinary matter $\Omega_b = 4\pm0.4\%$ (about I/10 visible)
- Space is flat $\Omega_{tot} = 1.02 \pm 0.02$
- Age I 3.7±0.2 billion years
- Universe will expand forever and its expansion rate is accelerating

WE ONLY REALLY KNOW 4% !!!!







"Pioneer anomaly" ???

Pioneer 10 (contact lost in 2003) and Pioneer 11 (contact lost in 1995) spacecrafts are travelling from Earth to beyond the Solar System. Pioneer 10 was traced to ~80 times farther from Sun than Earth, Pioneer 11 to about 45 times.

The most precise "navigation" data in space. A surprise - deviations between predicted and actual positions of both probes, additional acceleration towards Sun, $a \sim 10^{-9}$ m/s². The same anomaly was also seen in Ulysses probe, and possibly also in Galileo spacecraft, although data noisy, closer to the Sun as they were artificial satellites of Jupiter. The Viking spacecraft which travel to Mars did not show the anomaly, it should have as the tracking was precise enough (~10 meters).

Attempts to explain by dark matter in conflict with planetary orbits; modified theories of gravity perhaps the best candidates so far. what is the topology of the Universe? construction of a flat torus



what is the topology of the Universe? torus and its universal covering space



what is the topology of the Universe? the two-torus as connected sum of two flat tori









what is the topology of the Universe? multiconnected Euclidean surfaces

Name	FP and identifi- cations	Shape	Closed	Orientable
cylinder	a a b		NO	YES
Möbius strip	a b a		NO	NO
torus	c d a b c d		YES	YES
Klein bottle	a b d c d a b d c d b		YES	NO

· 2-dim torus (left); Universe could be 3-dim torus (right)





what is the topology of the Universe? multiconnected Euclidean surfaces



THE THEORY Observers looking at a portion of the universe in one direction... POINT AT WHICH THE UNIVERSE APPEARS TO REPEAT ... might see the same portion of the universe when they look in the opposite direction because it connects with itself.

what is the topology of the Universe? multiconnected Euclidean surfaces

no convicing evidence in the data, but 6 pairs of repeating circles found(?!)



some UNANSWERED QUESTIONS IN PHYSICS

• IS OUR UNIVERSE ROTATING ???

(it is possible, Kurt Godel wrote a paper in 1949 on such a solution to Einstein's equations for Einstein's 70th birthday !)

(this would show as the "preferred direction" such a universe would have closed time loops time travel?)

IS THERE A PREFERRED AXIS?

• WMAP results



IS THERE A PREFERRED AXIS?

Costa, Tegmark, PRD 74 (2006)

The quadrupole and octupole moments point in almost same direction (which is VERY UNLIKELY) and the directions are VERY stable when data is reanalysed under different data corrections



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120 fields this size would fit across the moon 200 billion galaxies at this brightness on whole sky



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VIRGO CLUSTER



GREAT ATTRACTOR



IS THERE A PREFERRED AXIS?

Longo, 2006:

study of handiness of galaxies in Sloan Sky Survey; THE SAME AXIS AS THE QUADRUPOLE AND OCTUPOLE MOMENTS IN WMAP DATA !!



A COLD SPOT?



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A COLD SPOT?



Adler, Bjorken, Overduin gr-qc/0602102

Are we close to the edge of the UNIVERSE??

are constants of nature really CONSTANT ???



some UNANSWERED QUESTIONS IN PHYSICS

QUANTUM MECHANICS

Feynman: "nobody really understands it..."

Is "wavefunction collapse" actually is a physical process?

Measurement theory ?

MORE UNANSWERED QUESTIONS IN PHYSICS

- quantum theory of gravity?
- do black holes exist?
- what is gravity?
- large scale quantum effects in our world?
- was there a Big Bang? what was before Big Bang?
- WHAT IS SPACE AND TIME? ARE THEY CONTINOUS OR DISCRETE (Planck' s length??)

FUTURE OF XXIst CENTURY PHYSICS?

- MANY QUESTIONS AND PUZZLES EXCITING !!
- NEW DATA in particle physics coming soon: LHC starting 2007, will take data for 10-15 yrs may yield discoveries and clues to physics beyond SM
- NEW satellites (PLANCK) later in this decade
- Mathematical physics may come up with a totally new and revolutionary idea

An OLD mystery: Titius-Bode law ???

Discovered by Johann Titius (1766) and published by Johann Bode(1772) without giving credit to Titius (?!)

original formulation: a=(n+4)/10, where n=0,3,6,12,24,48...modern formulation a=0.4+0.3m, where m=0,2,4,8,16,32...a=distance of a planet from the Sun in AU

	T-B	obs.
Mercury	0.4	0.39
Venus	0.7	0.72
Earth	1.0	1.0
Mars	1.60	1.52
asteroid belt	2.8	2.8
Jupiter	5.2	5.2
Saturn	10.0	9.54
Uranus	19.6	19.2
Neptune	-	30. I
Pluto	38.8	39.4

does not fit, but Neptune also rotates about anomalous axis

symmetries <=> conservation laws

- Symmetries observed in physics:
 - Symmetries of discrete space-time transformations: parity (space inversion), time-reversal, charge conjugation
 - Symmetries of continuous space-time transformations: translational and rotational invariance and Lorentz (space-time rotations) invariance
 - Symmetries of permutations: lead to two kind of particles: bosons, which obey Bose-Einstein statistics, and fermions, which obey Fermi-Dirac statistics
 - Gauge symmetries: internal symmetries inherent from the nature of the field associated with a given particle carrying such attributes as electric charge - U(1), color - SU(3) et cetera (conservation of electric charge <=> invariance under the global phase transformation in the internal space; electromagnetic field <=> invariance under the local phase transformation; et cetera....you' II learn all this in the future if you decide to study physics!!)

Connection between physics on small and large scales



85

COBE-WMAP Comparison



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Connection between physics on small and large scales



The cosmic microwave background Radiation's "surface of last scatter" is analogous to the light coming through the clouds to our eye on a cloudy day. We can only see the surface of the cloud where light was last scattered

Big Bang and CMB

- The cosmic microwave background (CMB) is a prediction of the Big Bang. The early universe was made up of a hot plasma of photons, electrons and baryons.
- As the universe expanded, the cosmological redshift caused the plasma to cool until it became favorable for electrons to combine with protons and form hydrogen atoms.
- This happened at around 3,000 K or when the universe was approximately 380,000 years old. At this point, the photons did not scatter off of the now neutral atoms and began to travel freely through space.
- Cosmological reshift continued with expansion

Results from WMAP

angular correlations in fluctuations of cosmic microwave radiation



89