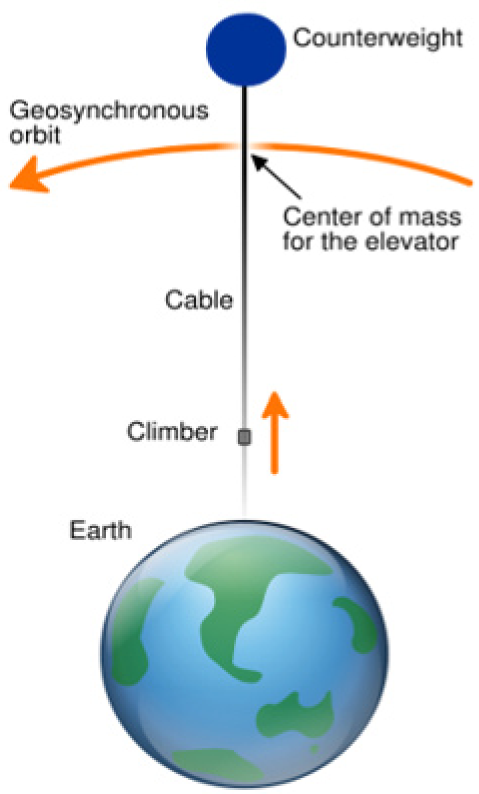
Tsiolkovsky and the Beanstalk

by Brady Nash

It would seem that, one by one, every science fiction idea published in books and comics is becoming a reality. What new idea do scientists have up their sleeves? The Space Elevator – as the name would suggest – is simply an elevator that starts on the surface of Earth and extends past our atmosphere into space. The elevator discussed in this article spans 22,000 miles but other models consider making the height larger. The idea was first derived by Konstantin Tsiolkovsky who was inspired by the creation of the Eiffel Tower. The concept of a space elevator was further illustrated in Arthur Clarke's The Fountains of Paradise. The main hurdle for constructing a space elevator was the lack of a practical material, but then came the carbon nanotube. As the name would indicate, carbon nanotubes are very small, yet extremely strong, carbon tubes. By weaving together thousands of miles of carbon nanotube ribbons, a space elevator may be possible. However, even if we can eventually create a ribbon cable for the space elevator, would it function and be safe? What would keep it from falling down or avoiding hazards such as space debris or hurricanes?

The elevator would be constructed so that the massive counterweight on the other end of the elevator would be placed in geosynchronous orbit with the earth. Allowing the top of the elevator to orbit at the same rate the Earth rotates, meanwhile the ribbon cable stays taut (like a rock tied to a string and spun in a circle above your head). To avoid hurricanes or random debris the bottom of the elevator could be installed with a mobile base using a tracking system to reposition itself in case the elevator was in danger of being damaged. NORAD, North American Aerospace Defense Command, tracks objects as small as 10cm but the tracking system implemented in the space elevator would need to track at least 1cm objects.
In the past few years, NASA's Centennial Challenge and



The Spaceward Foundation have teamed up to offer a prize of $400,000 to the team that creates the best space elevator prototype. The goal of the real space elevator would be to ship 13 tons of cargo at about 118 mph (and advance from there). While the competition allows teams to use solar power or spotlights to operate the climber, the space elevator's climber would be powered by free-electron lasers. All of this for a fancy FedEx? Sounds pricey. Although it will not be cheap, if fully operational, it will be much more affordable than the current shuttle program. The entire project is estimated at about $10 billion, whereas the shuttle program initially cost almost $20 billion and increases by half a billion dollars each additional spaceflight. It currently costs about $11,000 per kilogram to send supplies via the space shuttle, but the space elevator is predicted to only cost about $220 per kilogram.

For now, since the project would not be completed for another 10 to 20 years (being optimistic), we will have to wait and see if the space elevator remains in the science fiction section of the bookstore or towers above it.

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Respecting the Big W: Part 2

The Weak Force

by Steven Hochman

As mentioned in part one of this article, the W and Z bosons have mass while photons are massless. This posed a problem in developing electroweak theory. These particles are accurately described by an SU(2) gauge theory, but the bosons in a gauge theory must be massless. Some mechanism is required to break the SU(2) symmetry, giving mass to the W and Z in the process. According to the electroweak theory, at very high energies, the universe has four massless gauge boson fields similar to the photon. The gauge bosons are associated with a SU(2)×U(1) gauge symmetry. However, at low energies, the gauge symmetry is spontaneously broken down to the U(1) symmetry of electromagnetism. One explanation, the Higgs mechanism, predicts the existence of yet another new particle, the Higgs boson. In the 1970s, a few years after the development of the Higgs mechanism, evidence for both the W and Z were observed at CERN. As of 2009, despite intensive search for the Higgs boson carried out at CERN and Fermilab, its existence remains the main prediction of the Standard Model not to be confirmed experimentally.

The W and Z bosons decay to fermion-antifermion pairs. W bosons can decay to a lepton and neutrino or to an up-type quark and a down-type quark forming a meson, but they cannot decay to the higher-mass top quark. The weak force has a quantity associated with it such as mass to gravity or charge to electromagnetism. It is called weak isospin. It is one of the flavor quantum numbers. Particles not involved in the weak interactions have an isospin value of zero. Other elementary particles have weak isospin values of -1/2 or 1/2. Weak isospin is conserved in all interactions.

There are three basic types of weak interactions. These interactions can be represented by the vertices in a Feynman diagram. The two that involve the charged W bosons are called "charged current interactions". The third type involving the Z boson is called "neutral current interaction". A charged lepton (such as an electron or a muon) can emit or absorb a W boson and convert into a corresponding neutrino. A down-type or up-type quark can become the other by emitting or absorbing the appropriate W(+ or -) boson. Finally, either a lepton or a quark can emit or absorb a Z boson changing its spin.

The laws of physics were thought to remain the same under parity transformation, the reversal of all spatial axes. This law of parity conservation was

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who we are

UP is a monthly undergraduate physics newsletter sponsored by the University of Florida's chapter of the Society of Physics Students, for students, by students. We seek to strengthen the undergraduate physics community at the University of Florida by providing a forum for undergraduates to share their views and experiences with each other and to act as a source of information for opportunities and events in physics.

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what's UP in this issue

PHYSICS SHOWDOWN:

Condensed Matter *vs.* Materials Physics

by Victor Albert

Condensed matter physics, as reported in Wikipedia, is "the field of physics that deals with the macroscopic and microscopic physical properties of matter." Materials physics is "the use of physics to describe materials in many different ways such as force, heat, light and mechanics." These definitions reveal that there is often much overlap between these two sub-fields. However, there is a reason that we have two sub-departments, Condensed Matter Theory and the Quantum Theory Project, in the physics building. To clarify, the Quantum Theory Project is a theoretical and computational group that studies chemical, materials, and bio-molecular problems. With regard to the subtle distinctions between materials physics and condensed matter, I have amassed a series of conjectures from experts that try to organize these two highly overlapping fields.

Condensed matter physicists often have the fundamental desire to be able to explain the essence of a problem or an effect. Materials physics starts with the most fundamental description of a system and tries to expand the system size without losing all of the details and accuracy.

Materials physics methods try to find various effective approximations to the natural Coulombic Hamiltonian to account for "electron correlation." Condensed matter physics generally deals with "model" Hamiltonians for systems.

Condensed matter focuses on bulk materials (extended systems) with an infinite number of atoms. Materials physics includes investigations into molecular properties and surface interactions. The area where these two overlap is the area of "clusters," or groups of molecules such as quantum dots and fullerenes.

Materials physics is a name that was picked out of a slew of various buzzwords to describe a field of physics/chemistry that deals with a generally first-principles (ab-initio) approach to describing materials, surfaces, interfaces, and molecules. The list of buzzwords includes nanoscience, materials chemistry, solid state physics, physical chemistry, atomic/molecular physics, surface science, bionanotechnology, computational chemistry, chemical physics, theoretical chemistry, materials science, etc. These are fairly difficult to classify, but they do involve at least some methods of either of the two fields discussed above. Both of these fields are vital to the understanding of the properties of matter and maybe someday their unique approaches and methods will unite into one field.

For a great introduction into quantum chemical and materials methods as of today, please visit the website of the Director of the Quantum Theory Project, Prof. Erik Deumens, and look for the video lecture at the Mercury conference: http://www.qtp.ufl.edu/~deumens/Deumens_MERCURY_2009.mp4

Disclaimer: This article is solely meant as one person's opinion and the broad and generalized statements expressed in it do not purposely try to misrepresent any person's or any persons' respectable area(s) of research.

Weak Forces

Continued From Front

known to be respected by classical gravitation and electromagnetism; it was assumed to be a universal law. However, later work in the field suggested that the weak interaction might violate this law. The discovery of parity violation and renormalization theory suggested a new theory was needed to account for these asymmetries. In this theory, the weak interaction acts only on left-handed particles (and right-handed antiparticles).

This wouldn't seem physically logical if there were not some conservation taking place. This theory allowed a compound symmetry CP to be conserved. CP combines parity P (switching left to right) with charge conjugation C (switching particles with antiparticles). Physicists were again surprised however, when in 1964, clear evidence was provided that in kaon decays CP symmetry could be broken too. While CP symmetry violation exists in electroweak theory, it does not in Quantum chromodynamics, the theory of the strong interaction (color force). The reason for this apparent conflict remains an unanswered question.

Elite Impact:

TIM TEBOW *vs.* MARCUS GILBERT

by James Stankowicz and Victor Albert

Let's try to find with what velocity Tim Tebow's head contacted Marcus Gilbert's knee after being sacked by Kentucky safety Taylor Wyndham.

Assume Tim Tebow is a massive rigid, uniform, rod with mass m and height h.

Take the axis of rotation of the rod to be the ground, so that the center of mass is a distance $r = \frac{h}{2}$ from the axis of rotation.

Assume all of Wyndham's velocity V (with mass M) goes into rotating the rigid rod about its axis of rotation, and that energy is conserved.

So the [approximately] known quantities are: M, V (Wyndham's mass and velocity), m, h (Tebow's mass and height).

The velocity of Tim Tebow's brain is the rotational velocity of the rod, times the distance of the mass from the axis of rotation: $v_b = h\omega$.

The aim, then, is to find ω.

Conservation of energy gives:

$$mgh + \frac{1}{2}Mv^2 = \frac{1}{2}mv_{cm}^2 + \frac{1}{2}I\omega^2,$$

where $v_{cm} = \omega r = \frac{1}{2}\omega h$ is the velocity of the center of the rod.

I is calculated to be:

$$I = \frac{1}{3}mr^2 = \frac{1}{12}mh^2.$$

Solving for ω in the energy conservation equation:

$$\omega = \sqrt{\frac{2mgh + MV^2}{\frac{1}{3}mh^2}} =$$

$$= \sqrt{3\left(\frac{2g}{h} + \frac{M}{m}\left(\frac{V}{h}\right)^2\right)}.$$

This gives ω in terms of known quantities.

Now, as mentioned: $v_b = h\omega$:

$$v_b = h\sqrt{3\left(\frac{2g}{h} + \frac{M}{m}\left(\frac{V}{h}\right)^2\right)} =$$

$$= \sqrt{3\left(2gh + \frac{M}{m}V^2\right)}$$

The [approximate] numerical values of the known quantities are:

$$M = 231 \text{ lbs} = 104 \text{ kg}$$

$$V = 5 \text{ yds/s} = 4.57 \text{ m/s}$$

$$m = 240 \text{ lbs} = 109 \text{ kg}$$

$$h = 6 \text{ ft } 3 \text{ in} = 1.91 \text{ m/s}$$

Finally, calculate v_b:

$$v_b = \sqrt{3\left(2(9.81)(1.91) + \frac{104}{109}(4.57)^2\right)} = 13.1 \text{ m/s}$$

Any mere mortal might not have walked away from such an elite impact!