NEW ENERGY AGE

IS FREE UNLIMITED ENERGY REALLY A POSSIBILITY?

FIND OUT FROM TWO PHYSICISTS WHO HAVE EXPLORED THIS INTRIGUING TOPIC: HAL PUTHOFF AND STEVEN WEINBERG.

C_cox and other viewers ask:

I didn't quite understand the principle of zero-point energy on the show. Can you please give me a simple explanation of the basic theory or point me the direction where I could read about it on the web or a recent publication?

Hal Puthoff answers: A very readable summary can be found in Scientific American itself, in an article by Prof. Timothy Boyer in the August 1985 issue, entitled "The Classical Vacuum." As to the origin of the term "zero-point energy," it simply means that for any vibration (acoustic, electromagnetic, etc.) there remains, even at a temperature of absolute zero, a small residual energy that has its roots in the quantum uncertainty principle, a nonvanishing "quantum jiggle," as it were. In the context of the program, the possibility of an enormous reservoir of zero-point energy in space (the vacuum) associated with electromagnetic fields derives from the fact that although the residual energy at any given frequency is quite small (at the level of the uncertainty principle), there are contributions to the overall energy density from waves of all frequencies, propagating in all directions, and the sum of all these contributions is calculated to be quite large.

Steven Weinberg answers: Electric and magnetic fields and other fields are subject to a version of the Heisenberg uncertainty principle: t is not possible to have a state in which a field, and the rate at which it is changing, both vanish. Consequently empty space, even far from any matter, is permeated with continually fluctuating fields. The effects of these fields are very weak under ordinary circumstances, but they can be measured -- for instance, by observing a force between parallel metal plates due to the change produced by these plates in the fluctuating electric and magnetic fields in the space between the plates. This is known as the Casimir effect, and has been studied experimentally and theoretically for many years.

Cosmicaug asks:

This is a naive layperson's question which, as a genuinely naive layperson (at least when it comes to QM), I feel fully qualified to pose. The question is simply where does the energy in these quantum vacuum fluctuations come from? That is, if I installed one of these zero point energy devices in my basement to power my electric toaster in my kitchen, would I get free air conditioning in my basement every time I made toast or would the energy come from somewhere unknown (perhaps even somebody else's basement) or would it come from nowhere at all (free lunch scenario)? I am of course bypassing the issues of exactly how much of this energy is available and whether it is harnessable in some practical way and simply assuming that at some point I can buy these devices at my local hardware store and that they work as advertised.

Hal Puthoff answers: Naive layperson's questions are the best! If access to the zero-point-energy (ZPE) reservoir is successful, one needn't worry about either depletion of this resource or creating an imbalance in the local environment. It is the electromagnetic equivalent of scooping cupfuls of water out of the ocean, with replacement occurring at the velocity of propagation of electromagnetic waves, the velocity of light. As to the ultimate origin of the ZPE, two views are discussed in the physics literature: one, that it is simply part and parcel of the energetic legacy that emerged with the Big Bang, and another that it is an energetic substratum the preceded even the Big Bang, with our universe emerging as the result of a giant vacuum fluctuation. In any case an argument can be made that it is sustained by a cosmological feedback cycle in which charged particles radiate due to their "quantum jiggle," and the particles "jiggle" due to being caught up in the collective radiation of all the other particles, an electromagnetic equivalent of placing a microphone near a speaker and generating a squeal (see H. E. Puthoff, "On the Source of Vacuum Electromagnetic Zero-Point Energy," Phys. Rev. A, vol. 40, p. 4857,1989; Phys. Rev. A vol. 44, p. 3382,1991).

Gdecker asks:

For Hal Puthoff: You say you think the next century could be the era of zero-point energy. Do you think we’re close to finding the making the breakthrough discovery that would make this scenario a reality?

Hal Puthoff answers: To my knowledge there are at present five techniques proposed to extract ZPE for use, the more promising of which are under investigation in several laboratories, and some of which have shown some small positive results. As with solar power, hot fusion, and antimatter containment, the road between emerging laboratory proof-of-principle and scaled-up, economically-competitive energy resource is a long one. In our laboratory we are sufficiently optimistic that we are devoting a large part of our resources to this pursuit, with the expectation that within a decade we will either be confident that it is only a matter of time and engineering, or it will reveal itself to be only a laboratory phenomenon without the possibility of constituting a major energy resource. It falls into the category that we refer to jokingly as "high risk, infinite payoff," and so think it is worth pursuing until its potential is resolved one way or the other.

Bioteach asks:

Could you please evaluate the “bubble theory” that Puthoff is investigating on the show. Does it sound promising to you?

Hal Puthoff answers: The "Bubble Theory" presented on the Scientific American Frontiers program (that collapsing bubbles in cavitating fluids might act as a Casimir process to convert vacuum fluctuation energy into light) is not Puthoff's theory, but rather was proposed by Nobel Laureate Julian Schwinger in a series of papers published in the early '90's in the Proc. of the National Academy of Sciences. As one of several theories put forth to explain the phenomenon of sonoluminescence (sonically-driven light phenomena), this particular theory, if true, might show an excess of heat energy in careful calorimetric measurements, and these measurements are being carried out at the Institute for Advanced Studies at Austin. So far, no excess has been found, indicating that either Schwinger's proposed mechanism is not correct, or that the percentage excess energy is vanishingly small in the experiments carried out to date.

Jmartine asks:

Professor Weinber: In the beginning of the show during your conversation with Alan Alda, you talked about how humans have a desire to see themselves at the center of things. They seem to reject a rational, scientific viewpoint of their place in the laws of nature. I’ve been wondering why humans would have evolved with the former attitude - surely a rational view would serve us better. Any insights?

Steven Weinberg answers: It was naturally very difficult for human beings to develop a rational, scientific view of nature before the discoveries that led to the birth of modern science in the sixteenth and seventeenth centuries. Even so, there are those who tried, such as the Greek atomists Democritus and Leucippus, their followers, Epicurus and Lucretius, and the skeptic Xenophanes. But seeing a flash of lightning or the outbreak of plague, and having no idea what these phenomena were, it was almost irresistible to regard them as supernatural interventions aimed specifically at humans.

Toddm asks:

Professor Weinberg: I wish there had been time on the show for you and Hal Puthoff to debate the existence of zero point energy. Puthoff, for example, states that there is enough energy out in space in the volume of a coffee cup to evaporate all the world's oceans. You state that the energy in space the size of the earth is probably equal to no more than a gallon of gasoline. This seems like a big difference! Can you explain how you arrived at your estimate and why you think Puthoff is incorrect?

Steven Weinberg answers: We don't have a way of reliably calculating the energy in empty space. When we try to use our present quantum field theory to do this calculation, the answer in the simplest approximation comes out infinite, which is clearly nonsense. My estimate, that the energy in a volume of empty space the size of the earth is not greater than the energy in a gallon of gasoline, is a crude upper limit that was not based on direct calculations of the energy in any fundamental theory, but was based instead on observations of the way that the universe is expanding. If the energy density in empty space were much greater than this upper limit, it would produce enormous gravitational fields, which would mean that the universe would have to be expanding much more rapidly in order to avoid collapsing, just as a rocket leaving a heavy planet like Jupiter has to travel much faster than one that leaves a lighter planet like the earth. But (as I explained in a part of my interview with Alan Alda that was not broadcast) it really doesn't matter how much energy there is in empty space. The conservation of energy tells us that if we get energy out of empty space, then we have to leave it in a condition of lower energy. But what could have lower energy than empty space?

Hal Puthoff responds: As pointed out by Prof. Weinberg, a straightforward calculation using quantum field theory does indeed yield an infinite energy density for the zero-point energy (ZPE) of empty space. What's wrong with this calculation is the assumption that electromagnetic waves of all frequencies exist and contribute to this energy density. However, physicists Sakharov, Wheeler, and others argue that, because of quantum effects, the concept of a well-behaved spacetime geometry must lose its meaning as one approaches the so-called Planck frequency (wavelength ~10^-33 cm) where the geometry dissolves into a quantum "foam-like structure." Assuming a high-frequency cutoff at this frequency, they estimate an energy density which, though not infinite, might as well be for all practical purposes (mass equivalent of ~10^94 g/cm-cubed). Feynman, arguing that what counts is not the maximum frequency available in the ZPE background, but rather the frequency at which meaningful interactions between the background and nuclei cut off, reduces this estimate further to nuclear energy densities (~10^14 g/cm-cubed), still an exceedingly large number.

Why the remaining discrepancy between the high estimates given above by those who approach the problem from a quantum theoretical point of view, and the low estimates of those who, like Weinberg, approach it from a point of view of cosmology and gravitation? This discrepancy is symptomatic of a long-standing unresolved conflict between quantum theory and general relativity. If one assumes, as the cosmologists do, that the ZPE must contribute to spacetime curvature, then the lack of observable strong curvature must mean that the ZPE energy density is vanishingly small. However, the error may be in the assumption. Since this is an issue of high import, a search of the literature reveals several models that attempt to reconcile the conflict in other ways, e.g., by assuming a fine-tuned, negative-energy-density ZPE associated with fermions (e.g., protons, neutrons, electrons) that cancels that associated with bosons (e.g., photons), or that only mass-energy departures from the homogeneous ZPE background curve space.

In answer to the question "what could have a lower energy than empty space?" the answer is "an empty space with lower energy." Although one might naively assume that by definition the vacuum has zero energy and therefore can't go lower, a review of the literature shows that the vacuum state can have different energy values, and that a given vacuum state can under certain conditions decay to a state of lower energy (see, e.g., Fulcher et al., "The Decay of the Vacuum," Sci. Am., vol. 241, p. 150, Dec. 1979). In the Casimir effect, for example, in which plates are driven together by ZPE forces, the vacuum with metal plates far apart is more energetic than the vacuum with metal plates closer together, so the vacuum decays to a lower-energy state, transferring its energy (by the law of conservation of energy) into the kinetic energy of the plates moving closer, finally to be released as heat when the plates collide.

Students.was.mntm.org ask:

How did people first discover the concept of zero-point energy?

Hal Puthoff replies: This was an exciting example of the play back and forth between theory and experiment. In the early days of the development of quantum theory, a slight discrepancy was noticed between the calculated and measured energy levels of excited hydrogen gas. Although the calculations were carried out using the new quantum theory, no thought had been given to the concept that perhaps the atom did not exist in a void, but rather in a sea of fluctuating electromagnetic radiation. Once the possibility was taken into account that not only material systems but fields as well were subject to fluctuations associated with the quantum uncertainty principle, then the effects of field fluctuations on the electron orbits could be taken into account, and they were found to account for the discrepancy. Measurement of this discrepancy by Willis Lamb, now called the Lamb shift, led to a Nobel prize for Lamb, and further development of the understanding of the role of vacuum field fluctuations led to the development of quantum electrodynamics with its associated zero-point energy concept.

Nowadays, perhaps the most discussed demonstration of the zero-point energy concept is as follows. If a radio is taken into a shielded room, the stations can no longer be heard because the shielding stops the radio waves from entering. Similarly, closely-spaced metal plates slightly shield the interior region from certain frequencies of the fluctuating electromagnetic background ZPE. As a result, the radiation pressure of the waves between the plates pushing them apart is somewhat weaker than the radiation outside pushing them together. The force pushing them together is known as the Casimir force, named for its discoverer.

Students.was.mntm.org ask:

If you ever find more about this energy, how would you plan to heat a whole house? I thought that this subject was interesting. I think it would be interesting to use the energy around us to make heat or use it for other things to help us.

Hal Puthoff replies: If we are successful in finding a way to extract this energy on a scale large enough to be useful for such applications, and assuming that the process is efficient and environmentally friendly (that is, no harmful side effects such as radioactivity), then the most likely form it would take would be as a generator of heat. In this case a ZPE heater would simply constitute a stand-alone replacement unit for whatever heating unit is presently in use. If a process can be found to convert vacuum fluctuation energy into an electrical form efficiently, then batteries with an exceptionally long lifetime might result. However, I would also caution that it is too early to tell whether laboratory ZPE phenomena can be developed into a useful energy source. As with nuclear fusion, the steps between emerging laboratory results and market-competitive energy source are many. But, as the Chinese proverb says, a journey of 1000 miles begins with the first steps, and these steps are now being taken in many laboratories around the world.

Brittany asks:

I think the concept of a never-ending, free energy sources is fascinating! But I don't really understand why we haven't mastered it yet. The clock on the show represented how air pressure, or barometric pressure, can cause a simple spring to wind. Couldn't this technology be put to use in some other fashion, or if it's form didn't change, isn't there any way we can use it?? Thank you.

Hal Puthoff answers: Actually, when you think of it, there are a number of sources of the natural type (like the barometric pressure) that have been mastered and are used to produce energy. Niagara Falls is a good example, where the falling water drives turbines to drive generators to generate electricity. The water eventually is recycled by evaporation into rain clouds, then rain and the upstream river, with the energy recharge being accomplished by the sun in the evaporation part of the cycle. Geothermal activity in such places as Iceland is also used to produce energy. Solar power can be used effectively under certain conditions. There are even prototype devices to harness the tides and ocean currents, but these are not yet very effective. The use of fossil and nuclear fuels to release stored energy is, of course, a major example of the use of natural processes, in this case chemical and nuclear reactions. In this light, attempts to harness zero point energy are just a recent addition to a long list of harnessing energetic processes we find in our natural environment.

Ejaxon asks:

I've always been interested in space travel ever since I was very young. I was wondering if zero point energy could possibly power space ships. Could it? If it could then we could be making trips to farther off places than the moon and maybe I could go to Mars someday?

Hal Puthoff answers: Although it is still too early in the research to know whether the zero-point energy can be tapped at levels sufficient to power a space ship, without a doubt it would make an ideal fuel since it is presumably available everywhere in space and therefore need not be carried on board. A recent (August 1997) NASA workshop on "Breakthrough Propulsion Physics" at NASA's Lewis Research Center in Cleveland addressed this very possibility. I have myself explored this topic in an article this year, "Space propulsion: Can empty space itself provide a solution?" published in the Jan/Feb 1997 issue of "Ad Astra," the magazine of the National Space Society, headquartered in Washington, DC.

Twilcox asks:

If you can tap into zero-point energy, say to turn on some local light source, then does the energy regional depletion affect local gravitational fields as they evolve in time? If local energy gets restored through some kind of cosmic accounts balancing principle, does the second law of thermodynamics become a casualty of the new physics?

Hal Puthoff answers: Since zero-point energy fields are simply a special case of electromagnetic field distribution, I would assume that any regional depletion would be restored at the velocity of light, the EM equivalent of scooping cupfuls of water out of the ocean. Therefore I would not anticipate an evolving gravitational anomaly associated with the process. As for the second law, I do not see it in danger of becoming a casualty of the new physics (more precisely, the new application, as the physics is standard). For example, Casimir plates in the vacuum can be considered coupled to an open system, and when driven together by vacuum forces, the vacuum has decayed to a lower energy state and heat has been generated by the collision of the plates, pretty standard stuff. For a more detailed discussion of the thermodynamic aspects of zero-point energy extraction, see D.C. Cole and H.E. Puthoff, "Extracting energy and heat from the vacuum," Phys. Rev. E, vol. 48, p. 1562, 1993.