Through The Looking Glass

Temporal Communications & Applied Brane Theory

Through the Looking Glass

Temporal Communications & Time-Travel in Applied Brane Theory Physics

By Tim Ventura, Heinrich Päs, Thomas Weiler, and Sandip Pakvasa, June 11th, 2006

The 2003 Blockbuster movie Paycheck described a fictional device capable of sending information from the future to the past -- but if Dr's Päs, Pakvasa, and Weiler are correct, this technology may not remain fictional for long. These groundbreaking scientists join us to discuss the idea that neutrinos can jump into higher-dimensional states that allow faster than light travel to carry a signal back in time, as well as the implications of a new generation of ideas coming out of applied string & brane-theory physics...

AAG: Let's start out with the inside scoop on what the buzz is all about -- a New Scientist article about your joint-paper, "Closed timelike curves in asymmetrically warped brane universes". It predicts a real time-travel effect resulting from neutrino movement in higher-brane space. Can you give us a bit of a layman's overview on exactly what you were predicting?

Päs: In the New Scientist article you mentioned by Marcus Chown, we discussed the causality properties of a special kind of extra-dimensional spacetimes. In these spacetime's the extra dimension - or "bulk" - is asymmetrically warped in such a way that the speed of light varies with its position along this extra dimension. This allows for shortcuts through the extra dimensions.

Paycheck, 2003: Could sterile neutrinos make Philip K. Dick's fictional idea a reality?

Several interesting aspects of such spacetimes have been discussed before: they may help to solve the puzzle of why the universe is homogenous over distances having no causal contact in standard cosmology - and thus provide an alternative to an epoch of inflation in the early universe, as discussed by Dan Chung and Katie Freese; they might explain why the dark energy contribution to the Universe's energy budget is so small - it may actually leak into the extra dimension, as has been pointed out by Josh Erlich, Csaba Csaki and Christophe Grojean, and finally - if there are sterile neutrinos allowed to travel in these extra dimensions - it may solve an experimental anomaly observed in neutrino oscillation experiments, as has been demonstrated by us. In our recent paper we have pointed out that the effective superluminality of particles travelling in the bulk could also allow to send these particles back in time.

Weiler: Of course, for the model to have validity, Nature has to oblige us with 1) extra dimensions, 2) a warped spatial metric, and 3) sterile neutrinos. Individually, each requirement is not asking too much, but taken together, we may be begging her for too much.

AAG: You know, one of the compelling things about this paper is that you're doing real work in applied string & brane-theory physics, which is something that was unheard of even as recently as last year. It's been less 6 months since Dr. Lisa Randall told me that she wasn't aware

of any applied-physics research in this area, and I've already seen a paper on the Alcubierre warp-drive by Dr. Eric Davis and your work predicting form of time-travel on a subatomic level. What does this say about progress in string & brane theory research, and do you think that we're going to see more remarkable predictions from these emerging scientific models as they become more fully developed and accepted?

Pakvasa: Actually we would not say that we have made "a prediction"; rather we point out what some of the possible "applications" of the extra dimensions may be.

Päs: We also should add again, that our scenario involves a lot of "ifs". What we claim is that it may be possible to send gravitons or sterile neutrinos back in time, if there is an extra dimension, if this extra dimension is asymmetrically warped, and if there are sterile neutrinos which are allowed to travel in this extra dimension. While there might be good reasons to believe in these assumptions, as they provide solutions to present problems, none of them has been proven yet. In any case - if large extra dimensions - in one form or the other - are realized in Nature, there might be interesting applications we even don't dream about yet.

Dr. Heinrich Päs: Post-doctoral research associate at the University of Hawaii.

Weiler: We need to demonstrate a breach in the wall of the Standard Model of Particle Physics and standard General Relativity. If that happens, the flood of researchers will quickly flow through the crack to widen it. The LSND neutrino result, if validated soon by miniBooNE at Fermilab, would blow the wall of the Standard Model away.

AAG: I guess the best way to qualify the concept you've developed is to say that you're making a prediction of a time-travel effect by neutrinos, but that this prediction isn't going to immediately lend itself to the classic science fiction warp-drive that can transport people and equipment, right?

Pakvasa: Again, not prediction, but the possibility of a time travel effect for sterile neutrinos. And yes, to connect the time travel of sterile neutrinos to macroscopic objects is a far cry, and although not forbidden it seems to be forbidden at any kind of practical level.

Weiler: Perhaps in the distant future, we will evolve so that our consciousness resides in a ball of sterile neutrinos. Then we can teletransport ourselves. If the accelerating Universe is as it appears, we will need to do a lot of evolving just to survive the distant distant future.

AAG: Let's back up a second and talk about sterile neutrino's -- if I'm interpreting this correctly, these are a form of neutrino that's not connected to the physical brane that our traditional 4 dimensions of space-time are located in, right? However, isn't what makes them truly interesting is that they can "phase in and out" of normal time-space by conversion to normal neutrino's, making them something that can be shipped back in time & captured presumably at a given location?

Pakvasa: The sterile neutrinos are in the "bulk", that is the extra dimension as well as the brane; just like gravitons. They may mix with ordinary neutrinos, and hence ordinary neutrinos can oscillate back and forth between being ordinary and sterile. This is what makes the time travel possibility accesible to us living on the brane.

Päs: In this scenario actually the usual matter is special, in that it is confined to our 4-dimensional brane. It is described by open strings ending on this brane, and thus being attached to it. It can interact gravitationally and via Higgs boson couplings to the open strings that propagate in the extra dimension. Namely the graviton and the hypothetical sterile neutrino.

AAG: I think that one of the lessons that we've learned from Quantum Computers has been that while working with subatomic particles isn't as romantic as something like transporting a starship, it can still provide a powerful tool for processing information & communications. So even if a person can't use your model to travel back in time, it's possible to still play havoc with causality by sending messages to the past, right?

Pakvasa: Well, in principle yes. That is why all the usual paradoxes will raise their ugly head and the question of Hawking's conjecture come up to "solve" them.

Päs: It does solve the question why we didn't meet tourists from the future (they are not composed of sterile neutrinos or gravitons), but it still can jeopardize causality the way we are used to it. Quantum computing pioneer David Deutsch has actually come up with a many-world interpretation of quantum mechanics in which changing the past is possible, but consistent.

Weiler: If what we are suggesting were to be true, then I would want to build a gigantic neutrino detector to look for signals from the future, the past, and maybe especially, from the bulk connected to other branes.

Dr. Tom Weiler: Professor of Physics at Vanderbilt University in Nashville, Tennessee.

AAG: I've read science fiction plots about time-travel devices that can only travel as far back as the initial construction or operation of the receiver -- in this case, presumably a complex neutrino detector for probably a low bandwidth data transmission system. Do you think this might be similar?

Päs: This is a typical constraint on time travel scenarios - you can go back in time only as long as your path exists. In our case the extra dimension might exist forever, so signals might influence physics in the very far past.

For controlled signal exchange, however, the neutrino detector is necessary and you are right that this constrains the earliest possible neutrino detection. There are other constraints as well, depending on how strongly the extra dimension is warped, and how large the relative speed of the neutrino detector and source is.

AAG: On a more philosophical note, while numerous authors have written about time-travel & temporal communications technologies, one of the most interesting plots was in Arthur C. Clarke's "The Light of Other Days", in which he suggests that the ability to truly communicate across time might effectively end time itself from the observer's perspective. In his case, he was postulating a wormhole-camera that could truly see the past, basically making all of human history converge to a degree into the present, but your technology is also similar to Philip K. Dick's device portrayed in the movie "Paycheck" -- making it potentially even more powerful. Any thoughts on what this would do to time from a human social perspective?

Pakvasa: As you point out, many possible implications of such devices have already been thought about in science fiction and in physics literature. Since our device is a time travel device, many of these would apply to it as well.

Dr. Sandip Pakvasa: Professor of Physics at the University of Hawaii.

Päs: What exactly it would mean if we could travel back in time would depend on whether it would be possible to change the past and how physics will be consistent under these circumstances. In any case it might show that our present daily-life understanding about causality and time has to be dismissed.

Weiler: I like the idea of causality-violation destroying our concept of time. People have looked at two-time theories and found them inconsistent. How about a no-time theory? To quote the man himself, Einstein: "Time and Space are modes in which we think, not conditions in which we live."

AAG: Since I've mentioned wormholes, I should ask about exotic matter: this is a subject that's come up in the context of traversing or sending data through wormholes, and in the papers that I've seen presented in the past, the requirement comes out of a necessity for negative mass or an equivalent amount of negative energy. However, you're postulating that the exotic matter required for your experiment already exists, right -- in higher-dimensional brane space?

Pakvasa: Yes, the point is that in our scenario, the negative energy density is needed but only in the extra dimension(bulk), but not in the brane . The fact that we do not need negative energy density in the ordinary space-time is an advantage and this may be a good thing.

Päs: A problem with exotic matter is not only how to produce it, but that quantum fluctuations to its energy may actually explode and destroy the time machine.

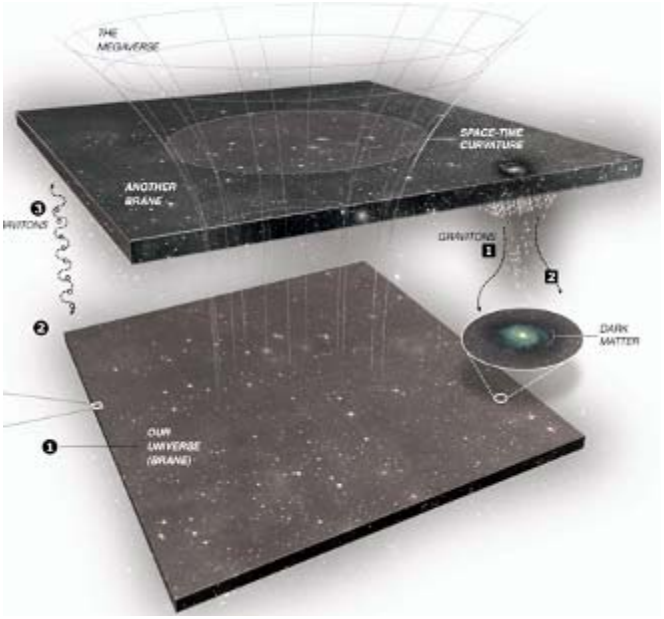
This behavior has been predicted for several classical proposals of time machines. While we didn't perform this calculation, the result may strongly depend on the number of dimensions, and our proposal may be stable against such quantum effects.

Weiler: An interesting feature that we did show is that on our brane, we can have positive energy but at the expense of having negative pressure. But this is exactly what one gets in a cosmology dominated by a cosmological constant, which is in fact the very one that describes our accelerating Universe.

AAG: Now one of the notions that surprised me was the idea of a "bulk", which I guess would be all of the extra-dimensions higher than the 4 traditional dimensions we see in normal time-space, right? In your model, are these dimensions curled up within the planck-distance as string theory has postulated in the past, or are they pervasive through the entirety of the universe? Maybe that's a trick question -- I've also heard that since these are higher-dimensions, then can be like micro-wormholes: both curled up into the planck-distance as well as being able to connect any two points in the universe. How do you visualize these dimensions in your model?

Pakvasa: The scenario we used corresponds to the so-called "large extra-dimensions", in which the extra dimension is not so small.

Päs: If the extra dimensions were small, particles could not penetrate very far. The model is similar to the warped scenarios of Lisa Randall and Raman Sundrum. It connects different points in our universe due to the warping: the measure of space shrinks in the extra dimension, while the measure of time stays constant, so that in the same time interval you can advance more space intervals. This produces the superluminality required for time travel.



Brane Bulk: If neutrinos jump to higher-dimensional spacetimes, they may travel backwards in time.

AAG: How does the notion of a "bulk" of hidden & disconnected dimensions above the normal 4 relate to Kaluza-Klein theory, in which a higher-dimensional time-space is inherently connected to our brane by deriving out into Maxwell's traditional equations for electromagnetism?

Pakvasa: The modern models of extra dimensions are inspired by the original ideas of Kaluza and Klein, but are inherently different. One is not trying to derive both gravity and electrodynamics from a single metric as they did. But they are now immortalised because the excitations in extra dimensions are called KK(for Kaluza-Klein).

Weiler: Yes, the model we explored has all quanta but gravitons and sterile neutrinos confined to the brain. This is quite different from Kaluza's and Klein's original work.

AAG: Now in terms of this extra-dimensional bulk, my understanding is that many of these extra-dimensions derive out of equations that don't fully explain what the dimensions actually are or contain. However, Kaluza-Klein hints that perhaps they may contain or may derive into new forces that we haven't encountered yet -- any thoughts on the possibility of completely new forces or phenomenon arising from the bulk that we haven't yet seen or even fully predicted?

Päs: Several new phenomena have been discussed by particle physicists and cosmologists. One prominent example is the Kaluza-Klein excitations of particles travelling in the bulk, which Sandip mentioned already. Another possibility is that gravity becomes suddenly strong as energy increases, and black holes could be produced in particle collisions. Such effects may be discovered by a future particle collider such as the LHC, which is under construction at CERN in Geneva.

Precognition: Will foreknowledge of future events violate the principle of causality?

Weiler: The bulk is used to explain not a new force, but rather an old force, gravity. The bulk explains why gravity is so inherently weak on the scale of particle physics. The sterile neutrino cannot mediate a new force, because it has the wrong spin (a long story). But if low mass spin zero or spin one "gauge singlet" particles are ever discovered, we could feel their long-range bulk force. The fact that we haven't felt them yet probably means they do not exist, or we do not have the right detectors for them.

AAG: Now when Marcus Chown wrote about your paper in New Scientist's "Head 'em off at the past", he invoked Hawking's "Chronology Protection Mechanism" as a potential mystery-limit preventing communication into the past, but that seems to be at odds with the Quantum Computing crowd's conviction that the "Many Worlds" interpretation of QM allows what we might perceive to be all sorts of violations of causality - including proven computational methods. Any worries about paradoxes?

Pakvasa: The chronology protection conjecture of Hawking is meant to just prevent all the paradoxical effects in presence of time machines, such as the grandmother paradox and self-consistency paradox etc. It has nothing to do with the Many worlds interpretation of QM.

Weiler: "Paradoxes" are never a worry; they are a signpost to better logic.

AAG: One area that I'm a little blurry on is whether the neutrino's travel instantaneously to a point in the past like we'd envision quantum-tunnelling or wormhole travel, or if they instead travel at a normal sublight-speed backwards in time. Is this splitting hairs, as to the observer it would have same effective outcome -- they appear out of nowhere and may contain useful information?

Pakvasa: The specific example we constructed corresponds to the following effect. We send a pulsed beam of neutrinos into the earth, let's say at time t. After conversion to steriles, reconversion to ordinary neutrinos, etc, we can bring some neutrinos back to the starting point arriving at time t'. If t' is earlier than t, we have a time machine and have travelled to the past.

Päs: In their own frame the particles always travel forward in time. But for an observer - or a neutrino detector - travelling with a relative speed as compared to the frame where the particle was sent off - the particle travels back in time.

Weiler: A common source of "paradox" is taking time as a physical entity common to all observers. Don't do that.

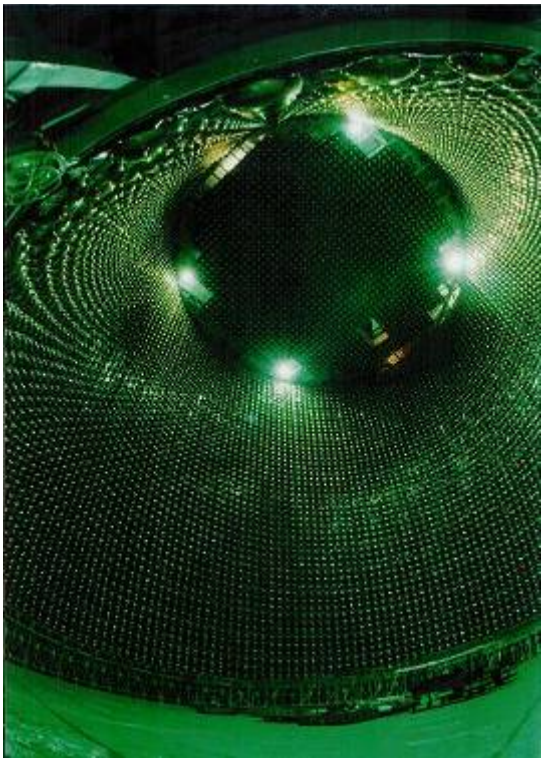
AAG: As a follow-on to the idea of travel-velocity, hypothetically speaking, how would you select a destination-time to send the neutrinos to? Would it involve calculating a specific distance of travel versus a negative progression of time, or is there some potential to tunnel these neutrinos as far back in time as required?

Pakvasa: Once the concept is established, the precise time difference, space point etc are all practical technical details....

Päs: The destination will depend on the properties of the extra dimension - the amount of warping - and the relative speed of neutrino source and detector.

Weiler: This is my favorite question in the lot. A related question is where in space will time-translated quantum arrive at? According to the geometric theory of General Relativity, all quanta should follow geodesics. Take a path from A to B which is a geodesic for particles stuck to the brane. Now take a sterile neutrino at A and send it on its geodesic into the bulk. It is not clear to me that it will ever show up at B.

What we showed is that there exists a shorter path through the bulk from A to B for the sterile, but there may be even shorter paths for it to go elsewhere. Some real CTC-engineering will be needed to make these little critters do what we want them to, like come back home to us, and of course, arrive at an earlier time.



Neutrino Detector: Could a detector like Kamiokande array in Japan pick up a signal?

The same could be said for the travel itinerary of gravity quanta (waves). I suppose a preferred geodesic taking gravity waves off the brane could prove problematic for experiments like LIGO and LISA which are proposed to receive gravity waves. I need to think about this more. We all need to think about these issues more.

AAG: The New Scientist article hinted that we may see additional support for your theory from the MiniBoone neutrino experiment at Fermilab, which may confirm the existence of sterile neutrinos when it goes online later this year. Any thoughts on what this experiment may tell us, and if it gives us a positive answer, have you considered how to potentially send a signal to it in the future that might be deciphered when it begins collecting data?

Pakvasa: The Mini-Boone experiment at FermiLAb is taking data now to check whether the effect(called LSND) seen 10 years ago in an earlier experiment at Los Alamos, is real. If yes, then that would be the first confirmed evidence that sterile neutrinos do exist and that they mix with ordinary neutrinos. So if this is confirmed, then our speculations about sterile neutrinos are at least about real objects!

Päs: Let me add that they even are able to confirm that sterile neutrinos take shortcuts in extra dimensions. Whether these extra dimensions are asymmetrically warped - and whether sterile neutrinos can be sent back in time, is a different question.

AAG: As we discussed before the interview, Marcus Chown is really an excellent science-writer, and his writeup on your paper made the front cover of the prestigious New Scientist Magazine, which really is quite an achievement. How does it feel to get such positive public feedback for your research, and what kind of feedback have you been getting from both the general public and the scientific community?

Pakvasa: Wonderful!

Weiler: I've received two handwritten letters of support from the UK. One from a retired GR practitioner, and the other from a thirteen year old schoolgirl who wants to write a SciFi novel about time travel. New Scientist does have a wide readership!

AAG: I'd like to close with sincere thanks for launching this tremendous work in applied string & brane physics, as well as ask about your future plans. Any thoughts about pursuing other far-out concepts in breakthrough propulsion or communications technologies for the future?

The Future Beckons: The next step for this team is engineering an experimental test.

Pakvasa: We would like to finish writing up our paper in which we discuss engineering aspects of a time machine based on our proposal in the first paper.

Päs: Besides this we are all involved in more conventional research, like figuring out how neutrinos acquire their tiny masses or what's the origin of highest energy cosmic rays, building models for particle physics beyond the Standard Model, as well as quark physics.

Weiler: I am involved in rather exciting topics in astrophysics. I am especially intrigued by the energetics and information content of black holes. And I suspect there is much to be learned about information and communication within the single biological cell. However, at 57 yrs, I begin to empathize with Yogi Berra when he said "Most of my future is behind me." It will take more than twenty more years to realize big advances.

Dr. Heinrich Pas is a post-doctoral research associate, and Dr. Sandip Pakvasa is a professor of physics – both are at the University of Hawaii at Manoa. Dr. Tom Weiler is a professor of physics at Vanderbilt University in Nashville, Tennessee. For more information, read "Closed timelike curves in asymmetrically warped brane universes" or New Scientist's "Head 'em off at the Past" .