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Email Correspondence

September 30 – October 4, 2015

PREFACE

As a philosopher/historian, Lombardi kindly informed me of a few references—earlier than Galileo—to the Earth-tunnel problem. A well-written Wikipedia article about the *Theory of Impetus* covers some of this history:

https://en.wikipedia.org/wiki/Theory_of_impetus

A more detailed historical treatment appears in one of a series of lectures from 1975–1977 by Reijer Hooykaas [published posthumously by Kluwer in 1999, *Fact, Faith and Fiction in the Development of Science*, Chapter 5] wherein we find that several Middle-Age scholars preceded Galileo. The idea of falling into a hole through the center of Earth was typically raised for the contrasting hypotheses it inspired as against the prevailing Aristotilian views on motion. For the sake of name-recognition (marketing) reasons, I continue to associate the problem primarily with Galileo instead of those less familiar ones who preceded him.

Note that the Wikipedia article characterizes the idea as "…one of the most important thought experiments in the history of science, namely the so-called 'tunnel-experiment'." Isn't it curious that a *thought* experiment of such stature *remains* as a thought experiment hundreds of years later, when, with the advance of technology it could fairly easily be turned into a scaled-down *real* experiment?

In the book referred to above, Hooykaas inadvertantly illustrates this contrast after discussing one of the earliest (14th century) predictions for the result of the experiment:

> Suisseth [Richard Swineshead] proceeded like Newton, or any modern theoretical physicist: a mathematically formulated working hypothesis is put forward and its physical consequences are found by mathematical deduction… the modern physicist will next try to test the conclusion by some experience of physical reality.

Sadly, Hooykaas joins the medieval scholars he writes about and the huge community of 21st century "modern physicists" in failing to advocate for an actual empirical test of the many "tunnel experiment" deductions—whether ancient or modern—"by some experience of physical reality." Paying lip service to the ideals of science does not count as living up to them. We do not yet really know whether a test object oscillates through the center of a larger massive body or not. As though ignorance were bliss, the "modern physicist" cares not a whit.

Another connection to Lombardi's work that I might have appealed to (if I had been aware of it) in my correspondence with her concerns the *direction of time*. Having discovered this work long after our correspondence ended, due to its profound importance, and direct

connection to Galileo's experiment, I'll briefly explain the matter here.

Though most of her writings concern the foundations of quantum theory, in a series of papers from about 2002 to 2013 Lombardi has also delved into

> *…the problem of the direction of time, one of the most longstanding debates on the conceptual foundations of theoretical physics.* [1]

Even after all their diligent work, it must be admitted, the contribution of Lombardi and her co-authors remains but one in a wide field of unsettled approaches to the matter. The gist of their argument is that, in conjunction with certain assumptions, the "geometrical properties of the universe," can be seen as perpetuating a particular temporal direction, i.e., *forward* (to the exclusion of its opposite, i.e., *backward*). This is presented as progress because the *dynamical laws* of physics are indifferent as to time's direction. Lombardi *et al* write:

> In general, the dynamical equations of fundamental physics are time-reversal invariant, e.g. the dynamical equations of classical mechanics, the Maxwell equations of electromagnetism, the Schrodinger equation of quantum mechanics, the field equations of quantum field theory, the Einstein field equations of general relativity. [1]

Thus, for the dynamical processes described by the fundamental equations of physics, backward is as likely as forward; a negative time variable is as logical as a positive time variable. So why is the forward direction "preferred" by Nature? Why does the time given by clocks only increase?

Lombardi *et al* argue that the unidirectionality of their global geometrical account of time "transfers" to local phenomena. They suppose the "energy flow" corresponding to the time direction of all local processes is a manifestation of the global temporal direction. In great detail they expound a constellation of "delicate points" needed to understand the picture. Note that the said energy flow refers to the multifarious motions of all matter and radiation everywhere.

> Once *we have established the substantial difference between past and future on global gounds* [original italics] and have decided that energy flows towards the future, we have a substantial criterion for discarding one of the [dynamically allowed temporal directions] and retaining the other as representing the relevant solution of the time-reversal invariant law. [1]

The "decision" that "energy flows toward the future" is, as noted above, based on a collection of "delicate points" whose purported global-to-local bridge remains, however, arguably fuzzy. I've included enough of their argument here to see its tentativeness ("once we've established…and have decided…") to provide contrast with a possibility that is neither delicate, fuzzy, nor based on a human decision, a possibility that is at once dramatically bold and physically unequivocal.

The heart of the new argument proposes that a more accurate model of gravity will turn out to be a paragon of *irreversibility*. Gravity's potently singular temporal direction, I would argue, is indicated by local accelerometers. (See Figures A and B on p. 4.) The appearance of and *assumption* that gravity (as described by Newton and Einstein) is a time-reversible phenomenon is due to a huge gap in our empirical evidence. We have not yet tested these theories *inside matter*, where the new model's validity would be most definitively determined.

One of the clearest demonstrations of the alleged temporal reversibility of gravity would be to conduct Galileo's *Small Low-Energy Non-Collider* experiment. A video of the predicted oscillation would look the same played forward or backward (cosine curve). If gravity is temporally unidirectional, on the other hand, (as suggested by accelerometer readings) then the test object will *not* oscillate; its path would approach an *irreversible*

asymptote to the center.

The global (cosmological) implications of the non-oscillation result—which are similarly dramatic, though somewhat less direct and tangible—have been discussed in a few of my papers. The upshot can be meaningfully related to some work by the late cosmologist, Sir Fred Hoyle. Hoyle, recognized that his Steady State cosmological model would have established time's arrow because it involved the *creation of matter*. In a 1962 lecture and paper concerning *The Asymmetry of Time*, [Australian National University, 1965] Hoyle wrote:

> *We can say that if the physical laws are such that matter is created then time's arrow is explained and understood.*

Though Steady State models have fallen out of fashion, it is worthwhile to note that Hoyle (as well as Bondi, Gold and even Dirac) contemplated creation of matter—the sudden appearance of individual particles—essentially out of nothing, out of the deepest voids of space. Even a glacially slow creation rate, spread out over cosmological space, would suffice to maintain the average cosmic density, as the galaxies were still envisioned as receding from one another (and gravity was still conceived as a force of attraction).

I call the gravity model that predicts a non-oscillation result for Galileo's experiment the Space Generation Model. It makes this prediction because one of its central tenets is that accelerometers tell the truth about their state of motion. An accelerometer co-moving with the falling object reads *zero*, so it is *not* accelerating. By contrast, accelerometers attached to the source mass (except at the center) all give *positive* readings. This suggests that *matter is an inexhaustible source of perpetual propulsion*. Which means matter continuously regenerates itself, so that cosmologically, we have "creation of matter," not by discontinuous new particles popping into existence, but by the *ceaseless increase of all matter that already exists*. The *process* whereby this happens, i.e., the regeneration of matter, the generation of space, the perpetual increase (upwardness) of time, and the resulting expansion of everything in the Universe (whose average density remains *constant*) is gravity.

Time only increases because space and matter also only increase. (Unification.)

Here then is another reason to build and operate humanity's very first Small Low-Energy Non-Collider.

Does gravity yank the test object back and forth in accordance with a time-reversible dynamical law? Or do the zero readings on a co-moving accelerometer, in conjuction with the non-zero readings on accelerometers attached to the source mass, result in a path that does not pass the center? The latter result would indicate most extremely unequivocally the *gross asymmetry, the emphatic irreversibility of space, matter and time*. By building and operating humanity's very first Small Low-Energy Non-Collider, we may at last see, in stark clarity, how time's arrow is to be "explained and understood."

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[1] Matias Aiello, Mario Castagnino, Olimpia Lombardi, 'The Arrow of Time: From Universe Time-Asymmetry to Local Irreversible Processes,' *Foundations of Physics*, vol. **38** (2008) pp. 257–292.

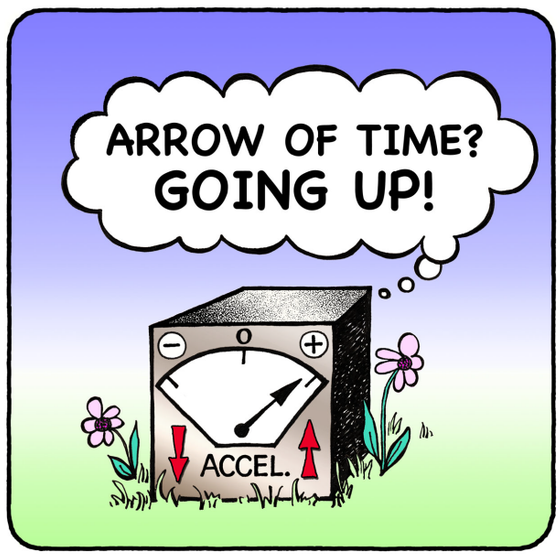

Figure A. If accelerometers are truthful about their state of motion, they seem to be telling us that the three basic elements of the physical world: *Matter*, *Space*, and *Time* are perpetually and *interdependently* increasing in proportion with one another. Corresponding to this possibility is that a test object falling in a hole through the center of a massive body will not pass the center. Whereas, if accelerometers are schizoid—as the prevailing relativistic perspective would have it—the test body will be yanked back and forth past the center even though a co-moving accelerometer reads zero. If the indicated arrow on the accelerometer corresponds also to the directions of matter, space and time, establishing this as an empirical fact would then represent a huge step toward revealing the essence of gravity and all that exists. The biggest unfilled gap in our knowledge of gravity and the physical world, is arguably the missing data corresponding to this experiment, which Galileo proposed 387 years ago. What are we waiting for?

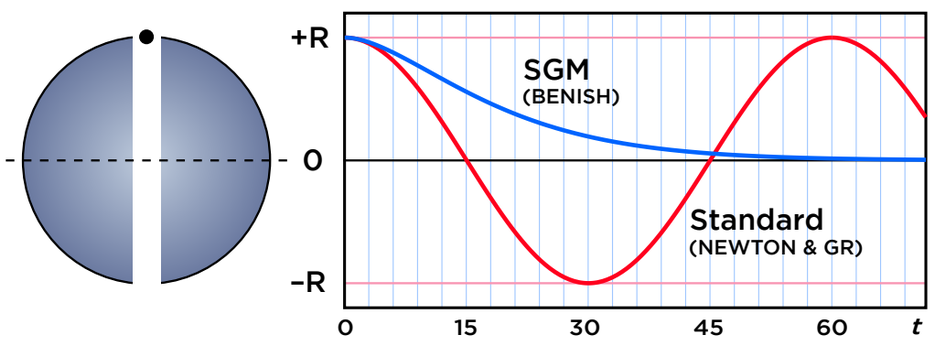

Figure B. Schematic of Galileo's experiment with graph of competing predictions: The standard textbook answer is that the test object executes simple harmonic motion (red curve). But in none of the many textbooks, papers, and classrooms where this prediction is given do we ever find empirical evidence to back it up. Even without a competing model, therefore, doing the experiment is a valuable contribution to science. For our particular purpose, the SGM's drastically different prediction (blue curve) would be unequivocally supported or refuted. The 60 minute oscillation period corresponds to a sphere whose density is about that of lead.

olimpiafilo@arnet.com.ar, 9/30/15 7:45 AM -0800, Galileo's Gravity Experiment **1**

To: olimpiafilo@arnet.com.ar
From: Richard J Benish <rjbenish@comcast.net>
Subject: Galileo's Gravity Experiment
Attachments: <Galileo's-Belated-Experiment.pdf> <Mr-Natural-Says-LR.pdf>

Dear Dr. Lombardi,

The attached paper argues that until we do Galileo's experiment, we cannot be certain whether or not an important stone in gravitational physics has been left unturned.

I hope you have some interest in filling this large gap in our empirical knowledge of gravity.

Thank you for your good work.

Sincerely,

Richard Benish

Olimpia Lombardi, 10/2/15 4:29 AM -0800, Fwd: Galileo's Gravity Experiment **2**

Date: Fri, 2 Oct 2015 09:29:09 -0300
Subject: Fw: Galileo's Gravity Experiment
From: Olimpia Lombardi <olimpiafilo@gmail.com>
To: rjbenish@comcast.net

> Dear Richard,
>
> You are right that the gap must be filled, but I'm not the right person to do that: I'm a philosopher of physics, not a physicist.
>
> Nevertheless, I can contribute to your work by saying that the first in proposing the experiment was not Galileo, but Jean Buridan in one of his *Expositio et quaestiones* on Aristotle's work: he predicted the oscillatory motion in terms of his theory of *impetus*. An the experiment was reproduced by his disciple Nicole Oresme, if I'm right, in his *Livre du Ciel et du Monde*, livre 1 chapitre 17. Middle Ages were not as obscure as many believe!!
>
> Very best
>
> Olimpia

Olimpia Lombardi, 10/2/15 7:39 AM -0800, Re: Fw: Galileo's Gravity Experiment **3**

To: Olimpia Lombardi <olimpiafilo@gmail.com>
From: Richard J Benish <rjbenish@comcast.net>
Subject: Re: Fw: Galileo's Gravity Experiment
Attachments: <Hole Through Earth.pdf> <SLENC as Clock Smalley 1975.pdf>

> Dear Dr. Lombardi,
>
> Thanks so much.
>
> I had a vague recollection of seeing an earlier reference to the experiment than Galileo's, but I could neither remember nor find it. I settled on citing Galileo's work because it is arguably more well

known and accessible (though still somewhat obscure).

Also, Galileo's discussion in his *Dialogue Concerning the Two Chief World Systems* is the earliest cited reference in the only paper I know of that explicitly addresses the history of the problem (see attached, p. 8). The attached paper focuses mainly on the last two centuries. You may find it interesting (surprising?) that Leonard Euler argued for a quite non-standard solution (p. 9).

More relevant to the present concern is the reference to the modern (1970s) space-based proposals to carry out the experiment, using the predicted oscillation as a clock by which to measure Newton's constant G. (See second attachment.)

Most important of all, as you've sensibly agreed, is that somebody should actually do the experiment to see whether Aristotle, Newton, or somebody else has made the right prediction.

Although I've evoked a few temporary sparks of interest, the many hundreds of physicists that I've approached about the situation ultimately seem quite content to leave the experiment undone, to leave the prediction untested.

The most noteworthy of these "sparks" may be that of Harvard Professor Gerald Holton, who wrote of my essay, "Nice… A very charming article." But nothing further. No expression of the need to turn the well known prediction into a physical fact. The status quo is thus maintained by PRETENDING to "know" the result. Not very scientific.

Therefore, any mention that you might make—as a philosopher, or simply as a curious human being—of the existence of this gap in our empirical knowledge of gravity would be greatly appreciated. I speak of course for myself, but also, I think, for the neglected spirit of Galileo.

Based on my experience, I should perhaps warn that any interest you may express in the need for empirical proof of the standard prediction will, in some circles, be met with scorn. So be careful and alert.

Thanks again for your thoughtful reply.

Cheers,

Richard Benish

Olimpia Lombardi, 10/4/15 3:18 PM -0800, Re: Fw: Galileo's Gravity Experiment **4**

Date: Sun, 4 Oct 2015 20:18:51 -0300
Subject: Re: Fw: Galileo's Gravity Experiment
From: Olimpia Lombardi <olimpiafilo@gmail.com>
To: Richard J Benish <rjbenish@comcast.net>

Dear Richard,

I suggest you to try to contact Professor Hasok Chang, from Cambridge, to send him your paper and the very interesting paper by Beech. He is a *very* famous philosopher and historian of science, particularly interested in what science discards or forgets: he thinks that the research on those forgotten parts of science may lead to a progress in science itself. Perhaps he might be interested in this very curious case.

My best regards and good luck!

Olimpia

Olimpia Lombardi, 10/5/15 8:02 AM -0800, Re: Fw: Galileo's Gravity Experiment **5**

To: Olimpia Lombardi <olimpiafilo@gmail.com>
From: Richard J Benish <rjbenish@comcast.net>
Subject: Re: Fw: Galileo's Gravity Experiment
Attachments:

Dear Dr. Lombardi,

Due to your suggestion, I've viewed Professor Chang's Inaugural Lecture at Cambridge and poked around some of his other work. Very refreshing.

Thank you very much for steering me in this direction.

I will follow up by sending Professor Chang the documents you recommended.

Gratefully,

Richard Benish

Dra. Olimpia Lombardi

Nombre: Olimpia Iris Lombardi
e-mail: olimpiafilo@arnet.com.ar

Formación de Grado:

- Licenciada en Filosofía por la Universidad de Buenos Aires.
- Ingeniera en electromecánica por la Universidad de Buenos Aires

Formación de Postgrado:

- Doctora en Filosofía por la Universidad de Buenos Aires.

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- Investigadora Principal de la Carrera de Investigador Científico y Tecnológico del Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)
- Adscripto a la cátedra de Metafísica, Facultad de Filosofía y Letras, Universidad de Buenos Aires.
- Profesora Adjunta Interina a cargo del Área Filosofía de las Ciencias de la Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires.
- Profesora Adjunta Regular de la materia Lógica en la Licenciatura en Sistemas, Facultad de Ciencias Económicas, Universidad de Buenos Aires.
- Docente Libre de Humanidades Médicas, Cátedra de Historia de la Medicina, Facultad de Medicina, Universidad de Buenos Aires.
- Asesora Científica en las asignaturas Epistemología y Metodología de la