Scott Aaronson

PROFESSOR of THEORETICAL COMPUTER SCIENCE

University of Texas at Austin

Email Correspondence

January 24–25, 2016

PREFACE

Although gravitational physics is not Aaronson's area of expertise, he ventured an interesting reply, revealing some knowledge of current empirical research. He was included in my list of possible correspondents, partly because of his membership in FQXi: *Foundational Questions Institute*. FQXi members include many prestigious physicists. The organization sponsors annual essay contests, three of which I have entered. Aaronson's professorship at U Texas has just started, coming after nine years at MIT.

Aaronson's reply is discouraging because it appeals to an illogical faith-based "counter-argument." Gravity experiments have to do with measurable quantities of distance, time, and matter, which are often found in practice as *mixtures* such as speed, acceleration, force, and angle (direction). As indicated by the figures on the following page, there is a huge gap in the *radial speed* vs. *distance* graph. I point this out in every attempt I make to generate interest in doing Galileo's experiment.

We have never observed how the speed of falling bodies changes between surface and center, *inside* gravitating bodies. Our *predictions* for how speed is *supposed* to change have never been tested. On his own blog Aaronson displays a quote from physicist Asher Peres: "*Unperformed measurements have no results.*" Is this not a call to action, a plea to do less *talking* about measurements (experiments) that *could* be done by actually *doing* them?

Many of my correspondents refer—explicitly or implicitly—to measurements of so-called *static forces* inside massive bodies. Such measurements may be carried out with torsion balances on a laboratory scale, and with seismic data on a planetary scale. They are *assumed* to correlate with the speeds supposedly produced thereby. This assumption is compounded upon the deeper assumption that a downward gravitational force is felt by *falling* bodies. Integrating the force over distance then gives the cumulative speed (squared) of a falling body as it changes inside. The oscillation prediction is a consequence of this kind of analysis.

Actually, however, the falling body *never* feels this alleged attractive force. A co-falling accelerometer *always* reads zero. As suggested by the *non-zero* (upward) readings found on accelerometers attached to the source mass, maybe the force is *only* felt by bodies that maintain contact. The gravitational force measured by an accelerometer is *always* upward, *never* downward. Insofar as this is an accurate characterization of the force of gravity, there is no reason to expect a falling body to pass the center, because nothing every forces it downward. Both possibilities cannot be right. Accelerometers either tell the truth or they don't. The test object oscillates in the hole or it doesn't. Only by doing the experiment can we test the validity of the standard assumptions and discover the facts of the matter.

Instead of perceiving this fundamental character of Galileo's experiment—i.e., that doing it would be a significant contribution to science even if it only confirms the standard prediction—Aaronson sides with the complacent status quo. Aaronson seemingly wants me to concede that there's no convincing reason to do the experiment because physicists are as *confident* in their *prediction* as they are in the impossibility of the Easter Bunny.

As if confidence counts for anything in the eyes of Nature. As if humans have not before deluded themselves about gravity and motion. As if science were impervious—without heightened awareness and persistent questioning—to the toxicity of faith in authority.

It's almost as fascinating as it is disheartening how virtually all members of the "scientific" community consistently fail to see the question marks on the following graphs as beckoning opportunities to deepen our knowledge of gravity. Instead they pretend; they carry on as if they already know, as if Nature's voice can be safely neglected. What a shame.

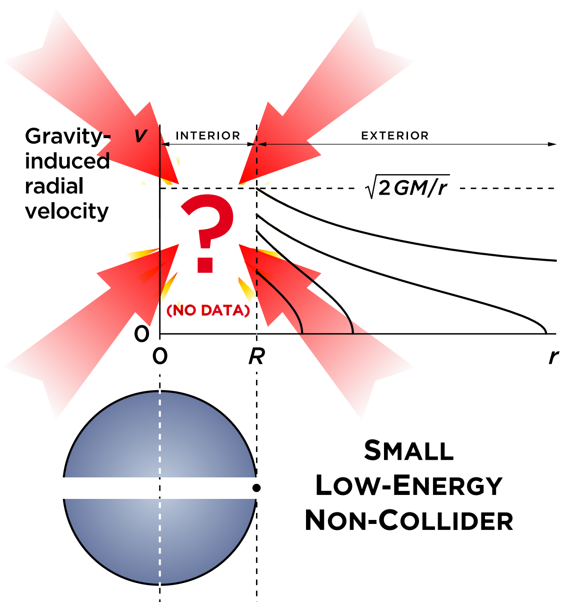
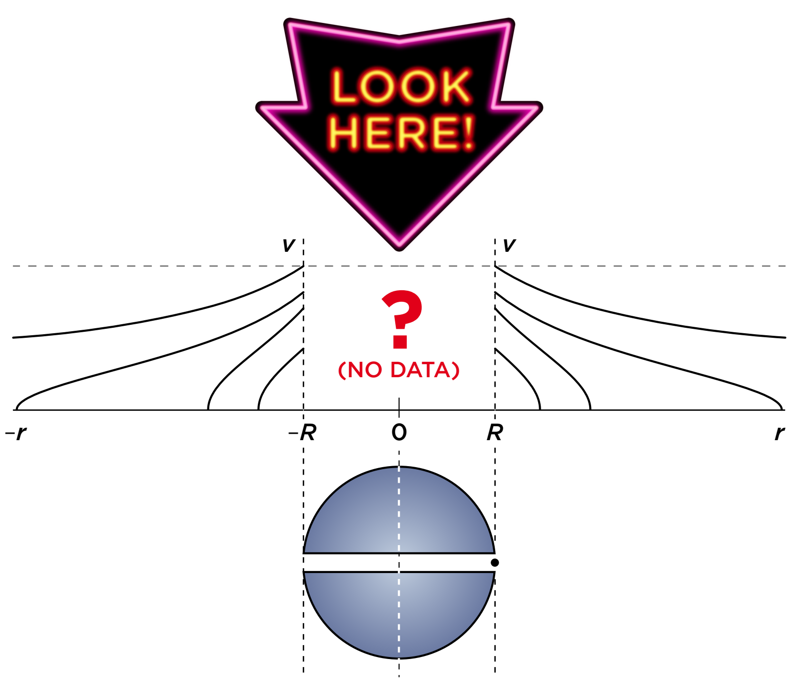


Figure X. Evidence gathered from above the surfaces of large bodies of matter like the Earth or Sun allow plotting the curves for the exterior region as shown. In the case of Earth, some evidence has been gotten from shallow holes close to (essentially at) the surface. But from well below the surface, especially near the center, we have no data. (As indicated, with some modest exaggeration.) The data is there to be gotten, not from astronomical bodies, but from laboratory sized bodies of matter. Instead of merely ***assuming*** that we know how to complete this graph for the interior region, conducting a preliminary demonstration on or near Earth would be a prudent first step before sending such a device to deep space.



Small Low-Energy Non-Collider

Figure Y. Huge gap in gravitational data. Almost all published evidence in support of Newton's and Einstein's theories of gravity is based on observations made *over* the surfaces of large massive bodies such as the Earth or Sun. Though discussions of the interior falling (i.e., Galileo's) experiment that would replace the question mark with data are common in physics classrooms and the literature, it has never been done. The results are therefore unknown, as indicated.

To: aaronson@csail.mit.edu
From: Richard J Benish <rjbenish@comcast.net>
Subject: Galileo's Gravity Experiment
Attachments: <Galileo's-Belated-Experiment.pdf> <Mr-Natural-Says-LR.pdf>
<Gravity-Sociology-2015.pdf>

Dear Professor Aaronson,

I hope you find the attached documents to be within your scope of interest.

I'd be grateful for any feedback.

Thanks for your good work.

Sincerely,

Richard Benish

On Mon, Jan 25, 2016 at 1:24 PM, Scott Aaronson <aaronson@csail.mit.edu> wrote:

> Hi Richard,
>
> Thanks for the paper! I'm hardly an expert, but I know that physicists now *can* measure the gravitational attraction between small terrestrial objects—indeed, there were experiments maybe a decade ago that tested Newton's law down to the ~1 millimeter range. And if you wanted, you could easily set up one of those experiments so that the gravitating objects were being lowered into a hole in the earth (not all the way *through* the earth, of course! :-) … but you could still measure the gravity from the objects). At least, that would seem like the obvious place to start, if you were serious about trying this sort of experiment.
>
> I'd caution you, however, that just because no one has tried some particular experiment, doesn't mean we can't have a clear expectation about the result. If you believe we can't, then you're open to the response:
>
> "Aha, but how do you know that the Easter Bunny won't suddenly appear, if we boil mangoes and celery in a purple cauldron in Greenland on February 14? After all, no one has actually TRIED that before! And even if we did try it, and it didn't work … well, how do you know it wouldn't work if we tried the same thing on March 23?"
>
> I fear that many physicists would see a breakdown of gravity in the situation you describe, as roughly as likely as the Easter Bunny appearing in Greenland. I'm sure you'd disagree, and that's fine! But my point is, the burden is on you to make the case to physicists, not merely that no one has tried this specific experiment before, but that there's a high enough chance that something new or exciting would come out of it to make it worth the effort.
>
> Hope that helps and best regards,
>
> Scott

Of course physicists can and do have "a clear EXPECTATION about the result." The question is, of what VALUE is this compared to an ACTUAL RESULT? The obvious answer is: NOT MUCH!

The value could even be NEGATIVE because an *untested expectation* may not only be wrong, it could result in delusional self-confidence.

To: Scott Aaronson <aaronson@csail.mit.edu>
From: Richard J Benish <rjbenish@comcast.net>
Subject: Re: Galileo's Gravity Experiment
Attachments: < Rethinking Einstein's Rotation Analogy.pdf > < Max Force Annotation.pdf > < Maximum Force Nov 17 2011.pdf >

Dear Professor Aaronson,

Ah, yes, the Easter Bunny maneuver—I've encountered it often. Robert Geroch used the variation of painted spots on the test object, observed by a male duck.

This maneuver is ineffective because:

An infinite number of variations can be dreamed up, each one as physically inconsequential as the others. The variations have no reasonably argued connection to the stripped down question at hand, which concerns only MASS and MOTION. Physicists are supposed to be interested in MASS and MOTION, not Easter Bunnies or male ducks.

Yes, we have data involving STATIC forces inside matter. One of the first was by Hoskins et al [*Physical Review D*, vol 32, no 12, pp. 3084-3095, 15 December 1985]. Since then, improvements have been made by the folks at U Washington and perhaps elsewhere.

We are of course free to GUESS what the consequence of these forces would be in the case of an object falling into a body of matter. Confidence in this guess seems to be reasonably founded on observations of falling objects OUTSIDE matter or near the surface. I get all that.

Yet gravity remains a big mystery. In terms of General Relativity, predicted kinematic consequences correspond to predictions concerning clock rates. In the present case, the predicted oscillation in the hole corresponds to the rate of a clock at the center of the source mass being a local minimum. What causes that? How do we know it is a minimum? We don't know, because the Schwarzschild interior solution has never been tested.

The gravitational field outside matter may be characterized as a domain where the acceleration g INcreases toward the center. Whereas inside matter g DEcreases toward the center. This domain inside matter, where the sign of the gradient of g reverses, has never been probed with respect to either clock rate or motion through the center.

This is therefore a rather large physical domain that we have left unexplored.

If you are not swayed by such physical arguments, then, out of respect for Galileo, ought we not to do the experiment anyway? In probably hundreds of physics classrooms every semester around the world, students are given the "hole to China" problem and its "answer." On the Internet Neil deGrasse Tyson is among the many figures shown falling into the hole, as viewers are told what supposedly WOULD happen.

https://www.youtube.com/watch?v=9d3d2fqi0Ok

In NONE of these cases is EMPIRICAL EVIDENCE given to support the predicted textbook answer. No good detective or curious child will be satisfied with this. Such researchers would, rather, want to see with their own eyes what actually happens; they want FACTS, not predictions or video simulations. Insofar as physicists may be likened to detectives and curious children, in my opinion, physicists should not be satisfied either.

Are we not therefore overdue to DISCOVER by OBSERVATION what actually DOES happen?

I've attached two papers that argue, one from an imaginary alien perspective, that the standard prediction for the experiment is indeed highly questionable. The result may indeed be a big surprise. I hope you have the time and curiosity to consider this perspective.

> > Thanks for your thoughtful reply.
> >
> > Sincerely,
> >
> > Richard Benish

On Mon, Jan 25, 2016 at 2:59 PM, Scott Aaronson <aaronson@csail.mit.edu> wrote:

> > > OK then, I guess there's nothing to say except that I wish you luck in getting your experiment done! I'm a theoretical computer scientist, not a physicist at all (let alone an experimentalist), so I almost certainly can't help you — but, I dunno, have you tried coming up with a cost estimate and a proposed design for your experiment?

To: Scott Aaronson <aaronson@csail.mit.edu>
From: Richard J Benish <rjbenish@comcast.net>
Subject: Re: Galileo's Gravity Experiment
Attachments:

> > > > Dear Professor Aaronson,
> > > >
> > > > Not your field: fair enough. I am grateful that you have engaged as far as you have.
> > > >
> > > > As to design and cost, my interactions with the apparatus-builder, George Herold at TeachSpin in Buffalo, NY provide rough answers.
> > > >
> > > > A few years ago I sent Dr. Herold an essay similar to the one I sent you, except that it included more detail on the "modified Cavendish balance" design. Herold replied:
> > > >
> > > > At 10:40 AM -0400 7/2/09, George Herold wrote:
> > > > > I have thought about doing exactly what is in your paper.
> > > >
> > > > In our later correspondence, I inquired as to the cost of having TeachSpin build the apparatus. By this time Herold had learned that I am an amateur. For that reason, I guess, he began to be a bit evasive; he would not give me a definite price. I attempted to light-heartedly close the correspondence with the quip: "Well I guess that pretty much confirms my guess. The device would cost about half a million bucks, give or take half a million bucks."
> > > >
> > > > To my surprise, Herold replied: "That sounds like some serious money."
> > > >
> > > > There's my estimate.
> > > >
> > > > To put it in perspective, note that a $2 million dollar experiment proposed by Craig Hogan has been characterized as "so cheap." [*Scientific American*, Feb 2012, p. 34.]
> > > >
> > > > The big question mark on the graph in my previous documents could be turned into data-filled facts, evidently, for less than a million dollars. Meanwhile, physicists pound their heads with Planck-scale stringbranes, inflatonic multiverses, and lots of Darkness. Guess who's not impressed?
> > > >
> > > > Good luck with your quantum computing efforts.
> > > >
> > > > Best regards,
> > > >
> > > > Richard Benish

The University of Texas at Austin
Computer Science

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Scott Aaronson - Quantum Computing

Ph.D. 2004, University of California, Berkeley

Quantum Computing
Computational Complexity

Scott Aaronson's research focuses on the capabilities and limits of quantum computers, and more generally on computational complexity and its relation to physics. His recent interests include how to demonstrate a quantum computing speedup with the technologies of the near future (via proposals such as BosonSampling, which Aaronson introduced in 2011 with Alex Arkhipov); the largest possible quantum speedups over classical computing; the computational power of closed timelike curves; and the role of computational complexity in the black hole information paradox and the AdS/CFT correspondence. In addition to research, he writes a widely-read blog, and has written about quantum computing for Scientific American, the New York Times, and other popular venues. His first book, Quantum Computing Since Democritus, was published in 2013 by Cambridge University Press.

Aaronson received his bachelor's from Cornell University, and his Ph.D. from UC Berkeley under Umesh Vazirani. He also did postdoctoral fellowships at the Institute for Advanced Study in Princeton as well as at the University of Waterloo. Before coming to UT, he spent nine years as a professor in Electrical Engineering and Computer Science at MIT. He's received the National Science Foundation's Alan T. Waterman Award, the United States PECASE Award, the Department of Defense Vannevar Bush Faculty Fellowship, and MIT's Junior Bose Award for Excellence in Teaching.

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"Unperformed measurements have no results." —Asher Peres