Research Argument

Gravity: The Inside Story

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Abstract. —
Given a uniformly dense sphere with a hole through its center, gravity is supposed to cause an object dropped into the hole to oscillate between the extremities. This is a prediction of both Newton's and Einstein's theories of gravity. Though every physicist knows what is *supposed* to happen, nobody has ever *seen* it happen. Failure to back up the predicted oscillation with empirical evidence is not due to insurmountable technical obstacles; a laboratory experiment to test it is quite feasible. According to the ideals of science, we should not be satisfied with analogies or extrapolations suggesting that the prediction is correct. We should, if possible, get the answer directly from Nature. Thus, we have two questions: 1) In the physical circumstance described above, *what happens*? And 2) Why don't we *find out* what happens? (1) is a physics question; its answer is non-verbal and is gotten by simply observing Nature. Whereas (2) is a more complicated, sociological question. Its answer involves the ways that physicists rescind the ideals of science; how they accept analogies and extrapolations as substitutes for facts due to the weight of authoritative "knowledge"—even though such knowledge lacks empirical evidence. These questions will be discussed in order.

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1. – Introduction

From the moment of birth, human beings, like other animals, learn how to deal with gravity without thinking about it. Though gravity remains mostly an unconscious part of our existence, thanks to Newton, Einstein and others, modern society has benefited from an understanding of gravity sufficient to send people to the moon and to maintain an impressive array of satellites. But there is a huge gap in our knowledge of gravity that physicists continue to neglect. We can predict well enough how planets and satellites move around large gravitating bodies. What has never been observed, however, is what would happen if a falling object were allowed to fall straight to the center of a larger body without collision. The orbiting of satellites and most everything else we know about gravity involves what is sometimes referred to as a gravitational *exterior* solution. Whereas falling to the center of a gravitating body involves what is referred to as a gravitational *interior* solution. *The standard gravitational interior solution has never been empirically tested.* It is obviously impossible to do a fall-to-the-center experiment by digging a hole through Earth. But it could be done relatively easily with more conveniently sized bodies in an Earth-based laboratory. For various reasons it is important to fill the gap in our knowledge of gravity by conducting an experimental test of the gravitational interior solution. Failure to do so up to now is not because of any insurmountable technical challenge. The thought of doing the experiment simply does not arise in the establishment of academic physics. The science of physics is not well served by leaving this stone unturned. My purpose is to bring this situation to light so that, ultimately, we can find out whether the standard gravitational interior solution is supported by empirical evidence, or not.

We need to first outline the history of our understanding of gravity. Fortunately, though gravitational physics can get very complicated, our concern will be a few simple facts about theories of gravity that we can meaningfully discuss in plain language and a few empirical facts about gravity that are similarly simple. This basic lesson will provide sufficient context to see the importance of the experiment mentioned above. Once we see that doing the experiment would be a worthwhile contribution to science, it becomes hard to avoid the question of why the physics community has neglected to carry it out. What we find is that this neglect is due to the weight of assumed knowledge, i.e., theoretical knowledge that is so deeply ingrained that physicists have ceased to question it.

2. – Basic background: History, theory, and physical facts

Gravitational physics mainly involves two theories: Newton's theory and Einstein's theory. The latter is known as general relativity. General relativity has proven itself superior to Newtonian gravity by agreeing with observations that disagree with Newtonian predictions. Currently there are no widely known viable alternatives to general relativity. In most cases the disagreements between these two theories are extremely small, so that Newtonian gravity is still more commonly used. In fact, the core curriculum of college physics throughout the world is Newtonian mechanics, which consists of Newton's laws of motion and, as a special case, his law of gravity. The deviations from Newtonian theory described by Einstein's theory become significant only in cases involving extremely high velocities or extremely massive bodies. Thus, general relativity retains much of Newtonian physics. It is fair to say that the prevailing understanding of the physical world is still deeply influenced by Newton's conceptions of space, time and matter—which are the fundamental elements of physics.

According to Newton's theory (which dates back to the 17th century) gravity is a force of attraction between material bodies. The bodies and the force are all envisioned as residing in the vast, possibly infinite expanse of *absolute space.* Newtonian matter possesses the property of inertia, which means that it resists being accelerated. Matter is conceived as consisting of a multitude of static, inert chunks of stuff. Newtonian space is conceived as a *flat*, passive background arena. Being flat means that it obeys the laws of Euclidean geometry. By contrast, one of the key innovations that Einstein introduced with general relativity (in 1915) is that space is described in terms of *non*-Euclidean geometry. Instead of being flat, space is *curved* or *warped.* In many popularizations of Einstein's theory the idea of warped space is depicted as a dimpled rubber sheet. Somehow matter is supposed to cause this dimple, which is sometimes characterized as an undulation in the *fabric of spacetime.* As implied by the word, space*time*, it is not only space that is warped; so is time. This means that gravity causes clocks to tick at different rates, depending on their location in the gravitational field. This is in contrast to the Newtonian conception, according to which time is unaffected by anything else. Newtonian time "flows equably," which means that all properly functioning clocks tick at the same rate no matter where they are located or how they are moving.

As noted above, Newtonian gravity successfully predicts the motions of bodies in the solar system; and where Newton's theory fails (by extremely small margins) Einstein's theory succeeds. Physicists are very happy with this. And yet, it is important to emphasize that we still do not know the inner workings of gravity. We don't know *why* Newton's theory seems to correspond to observations, nor do we know *why* Einstein's theory matches observations even better. In other words, we have no idea what *physical mechanism* could produce the force envisioned by Newton or the warpage envisioned by Einstein.

It is humbling to consider how some physicists have characterized our understanding of gravity. The well-respected cosmologist, J. Narlikar, has written, "It would be no exaggeration to say that, although gravitation was the first of the fundamental laws of physics to be discovered, it continues to be the most mysterious one." [1] An assessment by the English physicist, B. K. Ridley, is even more sweeping:

> Things in a force field start to move without anything visible pushing them. Pure magic, but we have talked ourselves into behaving as though such things are perfectly understandable...We think we understand. But really, we do not. The invisible influences of gravitation and electromagnetic fields remain magic; describable, but nevertheless implacable, non-human, alien magic. [2]

Another cosmologist, Michael Turner, puts it succinctly: "I think we are so confused that we should keep an open mind to tinkering with gravity." [3] The enigma of gravity persists not only with regard to the question of how material bodies produce it, it extends to various other unsolved puzzles, including the behavior of the universe as a whole, and to the question of how gravity relates to the other fundamental forces of nature. For many years physicists have been trying, without success, to find answers to these questions.

3. – Experiencing gravity for the first time

It often happens that the solution of a puzzle involves looking at it in a new way, from a new angle. So far, not surprisingly, gravity has been approached by humanity only as Earthlings would approach it. Perhaps that is the problem. We are so familiar with our experience of living on a large, warm, moist sphere of matter, that we have neglected to consider our gravitational experience from any other perspective. Therefore, let us now imagine that we are not inhabitants of such a place, but rather, that we have evolved in the far reaches of space where our experience of gravity would be much different. By adopting this perspective, perhaps we can expose a blind spot that we might otherwise not become conscious of. We will see that having the heritage of this civilization would mean that, upon discovering a large body of matter for the first time, we would instinctively have a burning curiosity to test the interior solution.

In addition to the unanswered questions about gravity mentioned above, the perspective we now adopt gives us one more poignant reason to look inside matter. Suppose, then, that we have evolved very far from any large gravitating bodies, so that we are essentially ignorant of gravity. Suppose our home is a huge wheel-like rotating space station—perhaps the size of a large city on planet Earth. This is possible because the *rotation* of the structure produces an effect very much like gravity. But the effect is clearly due to *motion*, not *mass*. Indeed, the present idea is to imagine that the mass of the station and all bodies that we are familiar with are too small for their gravitational effects to have been easily noticed. This immediately points up how rare it would be, cosmically speaking, to have a sphere of billions of trillions of tons beneath our feet (Earth). Most places in the universe are nothing like that. The mass of the space station is only a tiny fraction of Earth's mass, so its gravitational effects may well have escaped notice. Since this rotating world and its inhabitants will often be referred to in what follows, it will help to give them names. Let's call our imaginary home, the rotating space station, *Zarf*, and we, the inhabitants, *Zarfians*.

The ground of Zarf is the enclosed inner wall of our huge wheel. Let's assume that the speed of rotation is constant. Since the angular direction is constantly changing, this is an example of non-uniform or *accelerated* motion. Everything in contact with Zarf experiences a force due to this acceleration. The magnitude of this force can be easily measured with a device known as an accelerometer. Such a device is not unique to Zarf. On Earth they also have accelerometers that are exactly the same in design and function. By their name we correctly guess that these devices measure acceleration. Various carnival rides on Earth give an idea of how an accelerometer responds to rotation. The direction of acceleration is toward the hub, the axis of rotation. By constantly accelerating toward the axis, bodies in contact with the inner wall feel a constant pressure, just as Earthlings feel a constant pressure from the floor beneath their feet. The similarity of the effects in a rotating body (like Zarf) and on a gravitating body (like Earth) is well known. In fact, Einstein often referred to the analogy in discussions of general relativity. [4-6] The key point is that an *accelerating* floor produces effects that are *identical* to a floor on Earth that Earthlings customarily think of as being *at rest*.

The rotation analogy brings out a curious feature of Newtonian gravity. Newton's laws of motion apply to the experience of Zarfians not only while we are rotating, but also when we venture out of our home via rocket. In this case, too, the magnitude of our motion can be easily gauged with accelerometers. *In every case, whether rotating or accelerating via rocket, the direction of the force that produces the acceleration is the same as the direction of the acceleration itself.* To Zarfians, the truth of this seems a matter of course. What else could it be? Accelerometers measure acceleration and to make something accelerate a force is needed—a force that pulls or pushes in the same direction as the resulting acceleration. Very simple—and in accord with Newton's laws of motion.

Humanity's conception of gravity complicates this picture in a way that dramatically conflicts with the Zarfian experience. To accommodate the Earthling-invented idea of gravitational *attraction*, Newton's laws of motion are modified so that the direction of the force and the direction of the acceleration (as measured by an accelerometer) are *opposites* of each other! Back on Zarf, it was obvious that a falling accelerometer, i.e., an accelerometer not in contact with the station, will give a zero reading because it is not accelerating. It may appear to fall with respect to things that are in contact with the station because the latter things are accelerating, as reflected by their accelerometer readings. On Earth the physical facts are quite similar: falling accelerometers give zero readings; accelerometers attached to the floor give positive readings. The modification of Newton's laws of motion consists in the fact that an accelerometer that gives a positive reading is thought of by Earthlings as being at rest and an accelerometer that gives a zero reading is thought of as accelerating. To Zarfians this is complete nonsense. Instead, a positive reading should mean positive acceleration; a zero reading should mean zero

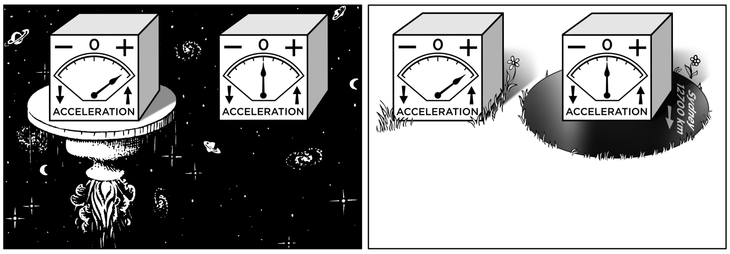

Fig. 1. – Left—Everybody believes the accelerometer readings. Right—To be consistent, Zarfians continue to believe the accelerometers. Whereas Earthlings insist that the positive reading means rest and the zero reading means acceleration. Whose logic is closer to the physical truth?

acceleration. Certainly this is the *simplest* interpretation. If we were to visit Earth, our instinct would not be to invent a law of "attraction" with its strangely inverted forces and accelerations. Rather, we would surmise that Earth's surface is accelerating upward. Back on Zarf, accelerometers are always, always, always counted on to tell us the magnitude and the direction of our acceleration. Being transported to Earth cannot change our deep instinctive trust in accelerometers. On Earth their readings tell us that the surface of Earth is accelerating upward. (See Figure 1.)

4. – Looking under the hood: A test of conflicting hypotheses

Reverting to our Earthian perspective, we are intrigued to discover that upward acceleration due to gravity is not a new idea even among Earthlings. For example, Sam Lilley has written, "The simplest interpretation of what we observe would be to say that we are accelerating upward." [7] Similarly, L. C. Epstein explained that, "Einstein's view of gravity is that things don't fall; the floor comes up!" [8] Epstein mentions Einstein because Einstein's *equivalence principle* was the first formal enunciation of the similarity of the effects of gravity and acceleration. But in each of these instances (among many others) the idea of the floor coming up is mentioned, but not pursued. The seemingly obvious reason is that, by the visual impressions that humans have relied on for all of history, we *see* the globe of the Earth as an essentially static thing. We do not see the Earth move. (This explains the tenacious resistance to letting go of the geocentric, pre-Copernican view of the solar system.) So this visual impression of a static Earth overrides our *tactile* experience (flattening of our undersides) which is reflected by accelerometer readings. If these readings are telling the physical truth, it means the state we call rest is actually a state of constant acceleration; it means the Earth and all matter is, in no manner whatsoever, static; everything moves outwardly.

Remarkably, this strange (to Earthlings) idea also predicts spacetime curvature quite similar to the curvature predicted by general relativity. [9] The details are beyond the scope of this paper. But the main idea is that this outward motion is now seen as the *cause* for the curvature of spacetime. In Einstein's theory matter is essentially static and it somehow causes spacetime to curve. In turn, spacetime curvature somehow causes things to move. Nobody has ever explained what makes this happen. How can something that is static make other things move? So the "Zarfian" idea is that there is no such thing as staticness. Matter generates and propels space, and by so moving, spacetime curvature is naturally explained.

Since these perspectives obviously contradict each other, the question arises as to how we could discover which one is correct, or at least, which one is closer to the truth. Is it more accurate to say that the floor accelerates upward or that the Earth's mass is a static thing endowed with a force of attraction? Should we believe the motion sensing devices (accelerometers) or the visual impression of staticness that we have inherited from antiquity?

Suppose the visiting Zarfians confer with their host Earthlings to resolve the matter. If the floor is really accelerating upward, this means that the matter of Earth must be an inexhaustible source of perpetual propulsion. The *engine* that propels Earth's surface ever outwardly resides in the huge amount of matter in its interior. So to determine whether this idea—which may seem crazy to Earthlings—is right or not, the Zarfians naturally think of inspecting the engine under the hood, the inside of material bodies. This is something that Earthlings had previously not thought to do. We have looked to the sky to study gravity but we have not before thoroughly considered looking inside matter to study gravity. The reason Zarfians think to look inside is that, if an object were allowed to fall into a hole going through the center of a large mass, its behavior would be much different, depending on whether gravity pulls things down or the floor really comes up. If gravity pulls things down, then the falling object would fall all the way through the sphere to the opposite end of the hole. But if the floor comes up, then the falling object would not pass the center. This is a huge difference, a difference whose consequences would be clearly distinguishable if this physical circumstance (dropping a small body into a hole through a big body) could be arranged. Finding out what actually happens will allow deciding between the Zarfian and the Earthian hypotheses of gravity.

It's obvious to everybody that the interior of Earth is inaccessible. But smaller bodies of matter should behave the same way. So our Zarfian-Earthling team devises an apparatus using spheres that would easily fit into a physics laboratory to conduct this interior falling experiment. One of the last references we need make to our imaginary visitors is to say that, in collaboration with Earthlings, they settle on an apparatus design similar to the one used by Henry Cavendish in 1798 to measure Newton's constant, G. [10] Such devices, known as torsion balances, have been used many times for gravity experiments, but never before with the modification needed to probe the interior. A schematic of the modified balance is shown in Figure 2. Among the many variations of torsion balance designs that have been used over the years, the one most well suited for adaptation for the present experiment (for reasons that are beyond the scope of this paper) is one built by Faller and Koldewyn in 1976. [11, 12] Suffice it to say that the experiment is certainly feasible with existing technology.

5. – Sociological aspects

Having established at least one compelling reason for doing the experiment and the fact that it could be successfully done, our focus will now shift. Up to now we have considered a few basic empirical and theoretical facts about gravity. We have learned that, for all the research that has been done, physicists are still very puzzled by gravity. Given this state of puzzlement, a natural question is, why have we left this interior falling question unanswered? Why has the experiment described above not been done? It will not do to say that it's because we have not been visited by Zarfians. Our first major question can be answered without a single word simply by observing Nature: Given a massive sphere with a hole through its center, when a small object is dropped into the

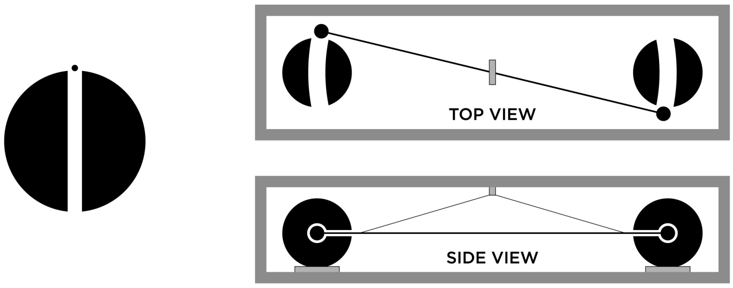

Fig. 2. – Left: Idealized (simplest) experimental method—sphere in outer space. Right: Practical experimental method—modified Cavendish balance in Earth-based laboratory.

hole, *what happens?* Our second major question, to which we now turn, is: *Why don't we find out what happens?* This question is not so easily answered because it involves the complexities of human society and the human psyche.

The first thing to note is that the literature of physics, to my knowledge, excludes virtually all discussion of the idea of doing the interior solution gravity experiment. I say *virtually* because in the 1960s and 1970s a few proposals were made for satellite experiments (to measure Newton's constant) that would have involved through-the-center motion. [13] If any of these proposals had been carried out, then we would already have our answer and I would not be writing this paper. But for various reasons they were not carried out. Note that the purpose of these experimental proposals was not to test or confirm the standard prediction for the motion of the falling object. This was taken for granted. So when the practical disadvantages of this kind of G-measurement were made clear, interest in such experiments disappeared. To my knowledge, there has never been any discussion of doing an interior solution gravity experiment in a laboratory on Earth.

This circumstance is in stark contrast to how common it is to find discussions of the theoretical *prediction* for the result of the experiment. In both elementary and advanced books and papers the "hole to China" problem is often discussed because its mathematical solution is simple and is related to other problems in physics. [14-24] But, to repeat, we find no discussion either of existing empirical evidence or of the need to gather empirical evidence to test the prediction. Therefore, I have personally inquired to physicists about this problem, suggesting that, if the experiment has not been done, then why don't we do it? Also I have submitted papers for publication to propose doing the experiment in scientific journals. Before presenting the key points in some of this correspondence, we need to be clear about what may be called the *ideals of science*—the science of physics, in particular.

6. – The ideals of science and communications with physicists

In a recent book about the history of the search for gravitational waves, Daniel Kennefick has referred to "the ideal type of scientist [as] one who has no time for received opinions unsupported by factual evidence or experimental data." [25] This ideal is very well known, as it traces back to 1663, when the Royal Society of London adopted the motto, *nullius in verba*. Many distinguished scientists have been members of the Royal Society, including Isaac Newton, who was its president from 1703 till his death in 1727. It still exists. On their website the motto is “roughly translated as, ‘take nobody’s word for it,’...and is an expression of the determination of the Fellows *to withstand the dominance of authority...and to verify all statements by an appeal to facts determined by experiment.*” [26] (Emphasis added.) The conflict is readily apparent: In classrooms all over the world, thousands of students are asked to “solve” the hole to China problem, having only a theory to do it with. To my knowledge, there is no case in which students are asked, much less encouraged, to seek empirical evidence to back up the “correct” answer. “Withstanding the dominance of authority” is thus clearly nothing but a lofty ideal, an ideal that is, in the present case, routinely ignored (one might even say, *trampled*).

Now let’s consider some of my communications with physicists. With the above ideals in mind, we first come to the response of astrophysicist, Marc Davis from the University of California, Berkeley to my inquiry concerning the interior falling experiment. Davis begins by confirming my research: “I agree that nobody has ever built an oscillator similar to what you describe.” [27] Then, on the basis of an analogy, he asserted that, “this type of oscillation is [not] only theoretical.” Davis explained that the *radial* motion of the falling object is supposed to be analogous to the *circular* motion of an orbiting satellite. I replied that the analogy might hold, but we don’t know for sure. So Davis replied again, suggesting another analogy, this time involving electricity. There is a mathematical similarity between the law for electricity and the law for gravity. But, I objected, the phenomena are in many ways quite different, so again, we cannot be sure the analogy holds without checking it empirically.

Davis nevertheless insisted that, “we are not ‘guessing’.” Going further, he concluded that “You must believe [Newton’s equations] because your life depends upon them every time you cross a bridge or fly in an airplane.” This is a very revealing assertion. With a little reflection, we can easily see that, actually, in the cases mentioned, my life depends on the properties of steel, stone, wood, aluminum, air, etc., not on equations that were invented many centuries after the first bridges were successfully built. (Nor have birds ever had any use for Newton’s abstract laws.) It is of course true that modern engineers use Newton’s equations to design bridges and airplanes. And the success of their products establishes the success of the equations *in these cases*. But the whole point is that Newton’s gravitational equations for the inside of matter have not been tested. Their success outside matter does not mean they work inside matter. Thus, Davis has committed the fallacy of misplaced concreteness. He regards his equations as substitutes for physical reality. He defers to the authority of abstract mathematical laws and relinquishes the scientific ideal that requires physical facts to back them up.

My next correspondent, the late distinguished professor of physics from the University of Texas at Austin, Bryce DeWitt, left me but two sentences: “The experiment you mention has never been done. It might be doable on an asteroid but the money could be much better spent on other things.” [28] Note first the lack of curiosity here with regard to the result of the experiment. Second, note that DeWitt’s reference to doing it on an asteroid could be taken to imply that the experiment might not be doable in an Earth-based laboratory.

In response to this I should mention my correspondence with Professor William Ingham at James Madison University and with the experimental physicist, George Herold, from Buffalo, New York. After consulting with colleagues, Ingham came to the conclusion that doing the experiment would be a “genuine accomplishment.” [29] That is, not easy, but doable. Herold works for a private company that builds experimental apparatus for institutions. In response to a paper of mine describing in more detail the apparatus discussed above, he replied, “I have thought about doing exactly what is in your paper." [30] Herold agreed that using technology similar to that used by Faller and Koldewyn would be a good and viable strategy. Unfortunately, both Ingham and Herold are too busy with other things to devote time to this experiment. This clearly implies (and their correspondence elsewhere confirms) that they too regard the result as a foregone conclusion. They both share the sentiment that, "yes, doing the experiment would be nice, but it is not a high priority because we can safely assume that we already know what the result would be." Though this lack of enthusiasm is disappointing, it is at least encouraging that the feasibility question implied by DeWitt can clearly be laid to rest.

The essay that generated positive responses from Ingham and Herold was submitted for publication to journals and to a Gravity Research Foundation essay competition. [31] One of these instances (submission to the *American Journal of Physics*) resulted in correspondence with the editor, Jan Tobochnik. He rejected the paper for publication because, "everything you discuss is already known." [32] This clearly implies that the *result* of the experiment is among the things that Tobochnik presumes to be known. He is thus not one of those ideal physicists who would seek "to verify all statements by an appeal to facts determined by experiment."

7. – Analogy and extrapolation

I could cite correspondence with many other physicists, to similar effect. But it is more beneficial to point out another aspect of scientific reasoning that comes into play here. One of the most common conceptual tools of the physicist—which we have already encountered a few times—is that of analogy. So useful and widespread is the use of analogy that the well-known physicist, Robert Oppenheimer declared that, "The notion of analogy is deeper than the notion of formulae." [33] The relationship between certain facts concerning rotational acceleration and similar facts concerning gravitational acceleration is an analogy, an analogy that extends also to linear acceleration, as by a rocket. One may build on the similarities as long as one does not go too far. Analogies always break down somewhere because two different things are not the same thing. I admit that the similarity between acceleration and gravitation does not prove that the floor really does accelerate upward. That's why the Zarfians proposed an experiment to find out how far the analogy goes. Davis, by contrast, argues for being satisfied and convinced by his analogy between gravity-induced radial motion and gravity-induced circular motion, and his analogy between gravity and electricity.

Analogies are similar to another tool in physics: extrapolation. In both cases the idea is to deduce what lies beyond our actual knowledge by mentally or mathematically extending the known into the unknown. If it's like this over here, we are free to assume that it's like this over there. But we don't know for sure that it's like this over there without actually going over there to see. Kennefick's description of the ideal scientist was partially inspired by another well-known physicist, Herman Bondi, one of whose outstanding characteristics is that of caution. His impression is that physicists are often too careless about drawing conclusions without sufficient evidence. Concerning the way this happens by unsubstantiated extrapolation, Bondi wrote:

> It is a dangerous habit of the human mind to generalize and to extrapolate without noticing that it is doing so. The physicist should therefore attempt to counter this habit by unceasing vigilance in order to detect any such extrapolation. Most of the great advances in physics have been concerned with

> showing up the fallacy of such extrapolations, which were supposed to be so self-evident that they were not considered hypotheses. These extrapolations constitute a far greater danger to the progress of physics than so-called speculation. [34]

Conscientious though Bondi has tried to be, his admonition is an example of advice that few would argue with but even fewer can consistently live by. To suggest that one should always insist on empirical evidence and never extrapolate or never assume to know what lies beyond the known is to deny our humanity. So the spirit of Bondi's remark is to as often as possible check one's foundation. Even concepts, principles and laws that we have long believed to be true should be re-inspected and subjected to new tests when the opportunity arises. In the present case it is clear that the confidence physicists (such as Davis, DeWitt, Tobochnik, et al) have in their prediction for the result of the *interior* solution experiment, is based on the success of their theories regarding *exterior* solutions. Mathematically they extrapolate from the exterior to the interior, and they assume that this extrapolation is valid. Taking Bondi's words to heart, we get the idea to *check* this assumption. Bondi's advice is another expression of the ideals of science.

8. – Folk memory: The image of physics and the image of physicists

It is not hard to imagine that if physicists actually lived by their ideals, then, upon hearing the suggestion to do an experiment that has not been done before, to look where no one has looked before, the response should be, "Yes, of course, lets do it!" To understand why I am not getting anything like this response (with the possible exception of George Herold) consider the following anecdote recorded by Kennefick in his book on gravitational waves. Kennefick, a young physicist, recounted his experience at a meeting where he began to address an audience of veteran physicists involved in gravitational wave research. In his opening statement, Kennefick referred to the time (in the late 1950s) when there were some doubts about the existence of gravitational waves. This statement was based on records in the literature. An older physicist in the audience (Bryce DeWitt) immediately objected that there had been no disagreement on this question. It was a tense moment. But then a few others in the audience recalled evidence in support of Kennefick.

This experience was recalled by Kennefick to illustrate a point about the sociology of physics. The point applies also to my experience. From his observations, Kennefick got the impression that physicists have a kind of "folk memory" according to which the historical development of physics is imagined in the best possible light. Thus he wrote: "There is a preference not to remember or not to overstress the significance of something which may be seen as vaguely disreputable to the field. It is a characteristic aspect of physics that to pose a problem or a question may, in itself, be taken as a sign of bad character." [25] The connection to my experience is that the experiment that I've proposed is one whose result has been assumed to be known for generations. All physicists know it so well that they "remember" it as a fact, not as something that still needs to be tested. To have it pointed out that the result is actually unknown because the experiment has never been done is to suggest that physicists have been, frankly, more than "vaguely" negligent. Only a person with "bad character" would point out such a thing.

As Kennefick makes clear, before a physicist acts as a physicist, he or she is likely to act as a social, political human being, a sensitive, proud, defensive human being. Which means his or her "folk memory" acts as a gatekeeper, as an outer protective layer to prevent entry of doubts about what is already collectively "known"—regardless of the non-existence of empirical evidence. For a physicist to admit that we actually do not know the result of the interior falling experiment would be, in a word, *embarrassing* to the field of gravitational physics. So they don't admit it.

9. – Conclusion

Before closing, it should be pointed out that, in the initial correspondence referred to above and in the rejected essay, there was no mention of the (equivalence principle-inspired) hypothesis that the floor comes up. These writings appealed only to scientific curiosity within the context of the standard paradigm. I made no suggestion that the result of the experiment would violate expectations. Kennefick's characterization of physics as having a "folk memory" is relatively new to me. But I might have deduced something like it from my experience. Thus I have long realized that my suggestion to do the experiment is enough (or too much) of a disruption to a physicist's received "knowledge" without compounding it with the seemingly far-fetched notion that gravity might not be a force of attraction.

By presenting the Zarfian perspective in this paper I reveal that my motive goes beyond "innocent" curiosity: Though it would be satisfying and valuable to confirm the standard prediction for the experiment, I have a hunch that the standard prediction is incorrect. Whatever the motive, there can hardly be any doubt that a perspective-shifting exercise like this is an intelligent and potentially rewarding thing to do. We've been looking from the same direction for millennia. So it is natural to wonder, what does the other side of our subject look like? Beneficial as this strategy may be, in a healthy scientific environment, the Zarfian perspective should not really be needed. It could be introduced or not. Either way, the fact that the experiment has not yet been done and that it could be done, should override all other factors. Being human, however, means being less than an ideal scientist. Tradition, dogma, authority, self-image, image of the profession—all these things are likely to come into play prior to the engagement with the open-minded, inquisitive scientist that lies beneath them.

Our knowledge of the effects of gravity outside material bodies gives physicists great confidence in our theories that best account for them, especially Einstein's theory, general relativity. But the various remaining mysteries of gravity allow the possibility for a theory that may agree equally well with all these exterior observations, yet make rather different predictions for the interior. Thinking of the interior as that which exists below our feet and the exterior as that which exists above, it becomes evident that our knowledge of gravity effectively excludes half of the visible universe—the most ponderous half, at that. Whether or not the Zarfian perspective proves correct when the interior solution experiment finally gets performed, it should now be clear that there is no good reason not to perform it—at least, no good reason that is consistent with the ideals of science.

REFERENCES

[1] Narlikar J., *The Structure of the Universe* (Oxford University, London) 1978, p. 140.
[2] Ridley J. K., *Time, Space and Things* (Cambridge: Cambridge University Press) 1984, p. 100.
[3] Overbye, Dennis, What is Gravity, Really? *New York Times*, (13 Nov. 2003) .
[4] Einstein A., *Relativity, the Special and General Theory* (Crown, New York) 1961, p. 80.

[5] Norton J., *What Was Einstein's Principle of Equivalence?*, in *Einstein and the History of General Relativity*, edited by Howard D. and Stachel J. (Boston: Birkhauser) 1989, pp. 5-47.

[6] Stachel J., *The Rigidly Rotating Disk as the 'Missing Link' in the History of General Relativity*, in *Einstein and the History of General Relativity*, edited by Howard D. and Stachel J. (Boston: Birkhauser) 1989, pp. 48-62.

[7] Lilley S., *Discovering Relativity for Yourself* (Cambridge: Cambridge University Press) 1981, p. 272.

[8] Epstein L. C., *Relativity Visualized* (Insight, San Francisco) 1988, p. 152.

[9] Benish R., *Maximum Force Derived from Special Relativity, the Equivalence Principle and the Inverse Square Law*, GravitationLab.com, <http://www.gravitationlab.com/Grav%20Lab%20Links/Maximum-Force-1-16-10.pdf>. Accessed 31 May 2010.

[10] Cavendish H., *Experiments to Determine the Density of the Earth*, extract reprinted in *Great Experiments in Physics*, edited by Shamos M. H. (Dover, New York) 1959, pp. 75-92.

[11] Faller J. E., *A Prototype Measurement of the Newtonian Gravitational Constant Using an Active Magnetic Suspension Torsion Fiber*, in *Proceedings of the 1983 International School and Symposium on Precision Measurement and Gravity Experiment*, edited by Wei-Tou N. (National Tsing Hua University, Hsinchu, Taiwan) 1983, pp. 541-556.

[12] Koldewyn W. A., *A New Method for Measuring the Newtonian Gravitational Constant, G*, PhD thesis (Wesleyan University) 1976.

[13] Chen Y. T., *The Measurement of the Gravitational Constant*, in *International Symposium on Experimental Gravitational Physics*, edited by Michelson P. F., En-ke H. and Pizzella G. (World Scientific, Singapore) 1988, pp. 90-109.

[14] Epstein L. C., *Relativity Visualized* (Insight, San Francisco) 1988, pp. 153-157.

[15] French A. P., *Newtonian Mechanics* (Norton, New York) 1971, pp. 144, 483-484.

[16] Giancoli D. C., *Physics for Scientists and Engineers* (New Jersey, Pearson) 2008, p. 393.

[17] Halliday D., Resnick R. and Walker J., *Fundamentals of Physics* (Wiley, New York) 1993, p. 419.

[18] Hodges L., Gravitational Field Strength Inside the Earth, *American Journal of Physics*, **59** (1991) 954.

[19] Misner C. W., Thorne K. and Wheeler J. A., *Gravitation* (W. H. Freeman, San Francisco) 1973, pp. 37-39.

[20] Tangherlini F. R., An Introduction to the General Theory of Relativity, *Nuovo Cimento Supplement*, **20** (1966) 66.

[21] Taylor N. W., Note on the Harmonic Oscillator in General Relativity, *Australian Journal of Mathematics*, **2** (1961) 206.

[22] Tipler P. A., *Physics* (Worth, New York) 1982, p. 362.

[23] Valens E. G., *The Attractive Universe: Gravity and the Shape of Space* (World, Cleveland) 1969, pp. 145-149.

[24] Wheeler J. A., *A Journey Into Gravity and Spacetime* (Scientific American Library, New York) 1990, pp. 55-65.

[25] Kennefick D., *Traveling at the Speed of Thought* (Princeton: Princeton University Press) 2007, p. 187 and p. 183.

[26] Royalsociety.org, *Nullius in verba*, History of the Royal Society, <http://royalsociety.org/Nullius-in-verba/>2009. Accessed 15 May 2010.

[27] Davis M., Email messages to the author, Re: Gravity-induced Oscillation, 31 Dec. 1995 2 Jan. 1996.

[28] DeWitt B., Email message to the author, Gravity Experiment, 17 Jan. 1996.

[29] Ingham W., Email message to the author, Re: Gravity Experiment, 26 Oct. 2009.

[30] Herold G., Email message to the author, Re: Gravity Experiment, 2 July 2009.

[31] Benish R., *Interior Solution Gravity Experiment*, GravitationLab.com, <http://www.gravitationlab.com/Grav%20Lab%20Links/IntSolGravExp-Apr-6-10.pdf>. Accessed 8 June 2010.

[32] Tobochnik J., Email message to the author, AJP: Decision on MS 22217, 13 Oct. 2008.

[33] Oppenheimer R., *On the Theory of Electrons and Protons*, in *The World of the Atom*, edited by Boorse H. A. and Motz L. (New York: Basic Books,) 1966, pp. 1199-1222.
[34] Bondi H., *Cosmology* (Cambridge, Cambridge University Press) 1952, pp. 6-7.