

The New Physics: The Speed of Lightness, Curved Space, and Other Heresies*

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Listwolme is a small world with a thin but permanently cloudy atmosphere. The inhabitants have never seen the stars, nor become aware of anything beyond their own planet. There is one main center of civilization which confined itself to a small region of the surface until about a hundred years ago, when an industrial revolution took place. For the first time, rapid transportation over substantial areas of the planet became possible.

Orbital velocity at the surface of Listwolme is less than two kilometers a second. The meetings of the Listwolme Scientific Academy following the development of high-velocity surface vehicles are chronicled below. The highlights of those meetings were undoubtedly the famous exchanges between Professor Nessitor and Professor Spottipon.

The first debate: In which Professor Nessitor reveals the curious results of his experiments with high-speed vehicles, and proposes a daring hypothesis.

Nessitor: As members of the Academy will recall, a few months ago I began to install sensitive measuring devices aboard the *Tristee Two*, the first vehicle to move at a speed more than ten times a running *schmitzpoof*. The work was not easy, because it was first necessary to suppress all vibration induced by the car's contact with the surface.

One month ago we achieved the right combination of suspension and vibration damping. It was with some excitement that I placed one of our instruments, a sensitive spring balance, within the vehicle and we began to steadily increase our speed. As you may have heard, there have been reports of "feeling light" from the drivers of these cars when they go at maximum speed.

Fellow scientists, those feelings are no illusion! Our instruments showed a definite decrease in load on the balance as our speed was increased. There is a relationship between *weight* and *motion*!

(As Nessitor paused, there was a murmur of surprise and incredulity around the great hall. Professor Spottipon rose to his feet.)

Spottipon: Professor Nessitor, your reputation is beyond question. What would arouse scepticism from another in your case is treated with great respect. But your statement is so amazing that we would like to hear more of these experiments. For example, I have heard of this "lightening" effect at high speeds, but have seen no quantitative results. Were your balances sensitive enough to measure some relation between the lightness and the speed?

Nessitor (triumphantly): With great precision. We measured the weight shown on the balance at a wide variety of speeds, and from this I have been able to deduce a precise formula between the measured weight, the original weight when the vehicle was at rest, and the speed of movement. It is as follows.

(Here Professor Nessitor went to the central display screen and sketched on it the controversial formula. It is believed that this was the first time it had ever appeared to public view.)

In the form that Nessitor used, it reads:

$$(\text{Weight at speed } v) = (\text{Rest weight}) \times (1 - v^2/c^2)$$

When the formula was exhibited there was a silence, while the others examined its implications.)

Spottipon (thoughtfully): I think I can follow the significance of most of this. But what is the constant, *c*, that appears in your equation?

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Nessitor: It is a velocity, a new constant of nature. Since it measures the degree to which an object is lightened when it moves with velocity v , I suggest that the basic constant, c , should be termed the “speed of lightness”.

Spottipon (incredulously): You assert that this holds anywhere on Listwolme? That your formula does not depend on the *position* where the experiment is conducted?

Nessitor: That is indeed my contention. In a series of experiments at many places on the surface, the same result was obtained everywhere, with the same velocity, “ c ”. It is almost four times the speed of our fastest car.

(There was a long pause, during which Professor Spottipon was seen to be scribbling rapidly on a scribe pad. When he had finished his face bore a look of profound inspiration.)

Spottipon: Professor Nessitor, the formula you have written has some strange implications. You assert that there is a lightening of weight with speed across the surface. This we might accept, but you have not taken your formula to its logical limit. Do you realize that there must be a speed when the weight *vanishes*? When $v = c$, you have a situation where an object does not push at all on the balance! Worse than that, if v *exceeds* your “speed of lightness” you would calculate a *negative* weight. If that were true, a car moving at such a speed would fly completely off the surface. You would have created the long-discussed and arguably impossible “flying machine.”

Nessitor (calmly): As Professor Spottipon has observed with his usual profound insight, the speed of lightness is a most fundamental constant. My interpretation is as follows: since it is clearly ridiculous that an object should have negative weight, the formula is trying to tell us something very deep. It is pointing out that *there is no way that an object can ever exceed the speed of lightness*. The speed that we can deduce from these experiments, c , represents the ultimate limit of speed that can ever be attained.

(Sensation. The assembled scientists began to talk among themselves, some frankly disbelieving, others pulling forth their scribe pads and writing their own calculations. At last a loud voice was heard over the general hubbub.)

Voice: Professor Nessitor! Do you have any name for this new theory of yours?

Nessitor (shouting to be heard): I do. Since the effects depend only on the motion *relative* to the ground, I suggest the new results should be termed the **Principle of Relativity**. I think that . . .

(Professor Nessitor’s next comments were unfortunately lost in the general noise of the excited assembly.)

Six months passed before Professor Nessitor appeared again at a meeting of the Academy. In those months, there had been much speculation and heated argument, with calls for more experiments. It was to an expectant but still sceptical audience that the Professor made his second address.

Nessitor: Distinguished colleagues, last time that I was here there were calls for proof, for some fundamental basis for the formula I presented to you then. It was to answer those calls that I embarked, four months ago, on a new set of experiments with the *Tristee Two* vehicle. We had installed a new instrument on board our car. It measures distances very accurately, and permits the car’s course to be controlled to an absolutely straight line. For it had occurred to me to ask the question, if velocity and weight are so closely linked, could it be that *distance* itself depends on some unknown factors?

Spottipon (somewhat irritably): With all due respect, Nessitor, I have no idea what you mean by such a statement. Distance is distance, no matter how you traverse it. What could you hope to find? I hoped that you would have repeated the experiments on speed and weight.

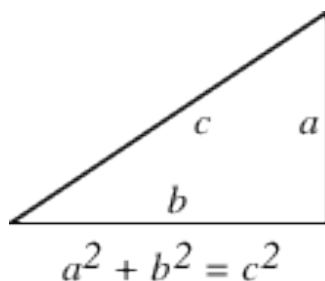
Nessitor: My esteemed colleague, please have patience. Permit me to tell you what happened. We set the *Tristee Two* to travel a long distance at various speeds. And indeed, we confirmed the speed-weight relation. At the same time, we were measuring the distance travelled. But in

performing this experiment we were moving longer linear distances over the surface of Listwolme than any other scientific group had ever done.

I therefore decided to conduct an experiment. We travelled a long distance in a certain direction, accurately measuring this with our new instrument. Then we made a half turn and proceeded far along this new line, again measuring distance all the way. Finally, we headed straight back to our original starting point, following the hypotenuse of the triangle and measuring this distance also.

Now we are all familiar with the Sharog-Paty Theorem that relates the lengths of the sides of a right-angled triangle.

(Nessitor went to the central display panel and scribed the famous Sharog-Paty relation:



There was a mutter of comments from behind him.)

Impatient voice from the audience: Why are you wasting our time with such trivia? This relation is known to every unfledged child!

Nessitor: Exactly. But it is not what we found from our measurements. On long trips—and we made many such—the *Sharog-Paty relation does not hold*. The further we went in our movements, the worse the fit between theory and observations.

After some experiment, I was able to find a formula that expresses the true relation between the distances a , b , and c . It is as follows.

(Nessitor stepped once again to the display panel and wrote the second of his famous relations, in the form:

$$\cos(c/R) = \cos(a/R) \times \cos(b/R)$$

There was more intense study and excited scribbling in the audience. Professor Spottipon alone did not seem to share in the general stir. His thin face had gone pale, and he seemed to be in the grip of some strong private emotion. At last he rose again to his feet.)

Spottipon: Professor, old friend and distinguished colleague. What is “ R ” in your equation?

Nessitor: It is a new fundamental constant, a distance that I calculate to be about three million paces.

Spottipon (haltingly): I have trouble saying these words, but they must be said. In some of my own work I have looked at the geometry of other surfaces than the plane. Professor Nessitor, the formula you have written there already occurs in the literature. It is the formula that governs the distance relations *for the surface of a sphere*. A sphere of radius R .

Nessitor: I know. I have made a deduction from this—

Spottipon: I beg you, do not say it!

Nessitor: I must, although I know its danger. I understand the teachings of our church, that we live on the Great Plain of the World, in God’s glorious flatness. At the same time, I cannot ignore the evidence of my experiments.

(The Great Hall had fallen completely silent. One of the recording scribes dropped a scribe pin in his excitement and received quick glares of censure. It was a few seconds before Nessitor felt able to continue. He stood there with head bowed.)

Nessitor: Colleagues, I must say to you what Professor Spottipon with his great insight realized at once. The distance formula is identical with that for distances on a sphere. My experiments suggest that *space is curved*. We live not on a plane, but on the surface of an immense sphere.

(The tension crackled around the hall. The penalty for heresy (smothering in live toads) was known to all. At last Professor Spottipon moved to Nessitor's side and placed one hand on his shoulder.)

Spottipon: My old friend, you have been overworking. On behalf of all of us, I beg you to take a rest. This "curved space" fancy of yours is absurd—we would slide down the sides and fall off.

(The hall rang with relieved laughter.)

Spottipon: Even if our minds could grasp the concept of a curved space, the teachings of the Church must predominate. Go home, now, and rest until your mind is clearer.

(Professor Nessitor was helped from the stage by kind hands. He looked dazed.)

For almost a year, the Academy met without Nessitor's presence. There were rumors of new theories, of work conducted at white heat in total seclusion. When news came that he would again attend a meeting, the community buzzed with speculation. Rumors of his heresy had spread. When he again stood before the assembly, representatives of the Church were in the audience.

Professor Spottipon cast an anxious look at the Churchmen as he made Nessitor's introduction.

Spottipon: Let me say how pleased we are, Professor Nessitor, to welcome you again to this company. I must add my personal pleasure that you have abandoned the novel but misguided ideas that you presented to us on earlier occasions. Welcome to the Academy!

Nessitor (rising to prolonged applause, he looked nervous but determined): Thank you. I am glad to be again before this group, an assembly that has been central to my whole working life. As Professor Spottipon says, I have offered you some new ideas over the past couple of years, ideas without fundamental supporting theory. I am now in a position to offer a new and far more basic approach. *Space is curved, and we live on the surface of a sphere!* I can now prove it.

Spottipon (motioning to other scientists on the stage): Quick, help me to get him out of here before it's too late.

Nessitor (speaking quickly): The curvature of space is real, and the speed of lightness is real. But the two theories are not independent! The fundamental constants c and R are related to a third one. You know that falling bodies move with a rate of change of speed, g , the "gravitational constant". I can now prove that there is an *exact* relation, that $c^2 = g \times R$. To prove this, consider the motion of a particle around the perimeter of a circle ...

(The audience was groaning in dismay. Before Nessitor could speak further, friends were removing him gently but firmly from the stage. But the representatives of the Church were already moving forward.)

At his trial, two months later, Professor Nessitor recanted all his heretical views, admitting that the new theories of space and time were deluded and nonsensical. His provisional sentence of toad-smothering was commuted to a revocation of all leaping privileges. He has settled quietly to work at his home, where he is writing a book that will be published only after his death.

And there were those present at his trial who will tell you that as Nessitor stepped down from the trial box he whispered to himself—so softly that the words may have been imagined rather than heard— "But it *is* round."

Find and read the short story *The New Physics: The Speed of Lightness, Curved Space, and Other Heresies* by Charles Sheffield, and answer the questions below.

1. Prove the standard Sharog-Paty Theorem quoted in the story without using any trigonometry. [4]

Hint: All else failing you could look it up, if you can recognize what it's called outside of the story. :-)

2. Prove the spherical version of the Sharog-Paty Theorem, also quoted in the story. You may use all the trigonometry you want to do so. [4]

Hint: It might help to review the lectures on spherical geometry. You may use the formulas and results given in those lectures. :-)

3. Give all the references you can find in *The New Physics* to actual persons, mathematical results, and physical theories, as well as historical events. [2]

NOTE: There are *lots*, and not all the references are to well-known things ...