Re: Bending of light not well authenticated

Source: http://sci.tech−archive.net/Archive/sci.physics.relativity/2005−05/msg01094.html

- *From*: "Randy M. Dumse" <rmd@xxxxxxxxxxxxx>

- *Date*: Sun, 15 May 2005 19:08:31 −0500

"Koobee Wublee" <kublai@xxxxxxx> wrote in message
news:QtBhe.33000$fI.5096@xxxxxxxxxxxxx
> How would the photon behave in proper spacetime?

Proper spacetime implies proper time of a local observer. In a local non−accelerated frame, the speed of light is always c. However, if the frame is accelerated, light appears bent/slowed.

And actually, one can construct an explanation of the bending of light by setting up a series of local frames, and following the net effect of all those frames across the path of the photon. Will does that very nicely in "Was Einstein Right?".

> According to GR, the spacetime of a photon is always equal to zero.
> So, we have
>
> c^2 dt^2 − ds^2 = 0
>
> Where
>
> ** dt = proper time
> ** ds = proper space

Hummm... generally the zero is on the other end (but it is an equation after all). Also the community uses d\tau for proper time, although I see you've noted dt as proper time. That's okay, but then, what do you use when you want to use dt in its normal sense (far−way, non−local time). Same with ds^2 which is usually the interval, rather than the space. The more normal representation of what you are saying might be

ds^2 = dx^2 + dy^2 + dz^2 − dt^2

but I'm sure I've seen notation similar to what you're using, ... but I don't know where. In anycase the interval for light is zero as you say, and so in my notation this would be the same as

0 = dx^2 + dy^2 + dz^2 − dt^2

or put another way

dx^2 + dy^2 + dz^2 = dt^2

which is the same as saying:

Light moves equal distances in space and time.

Or in another way, meaning about the same, light always moves at 45 degree angles in space time diagrams.

But in all these cases, we are talking about flat space. The flat space of Special Relativity and Minkowskian spacetime. The flat space also appears in the Schw. solution, if r becomes very large, such as if we are very far from the gravitating body, because the curvature term (1−2M/r) as r −> inf. simply becomes 1 so the effects of curvature fade away with distance.

> Clearly, the photon should behave with no anomaly in its orbit in the
> reference frame of spacetime. At infinite distance away where the
> gravitational effect of the sun is asyptotically approaching zero,

Correct, but, there is no "orbit" to have an anamoly in flat spacetime. No curvature, not orbit, no deflection, no problem.

> I still would not observe a deflection in the photon using the
> parameters of the proper spacetime.

As long as we also stipulate that the proper spacetime observer is not accelerated.

> So, with no bending of the photon in proper spacetime, it should also
> be reasoned that in observed spacetime, where the perception
> of the curvature in spacetime does take place, the photon undergoes no
> deflection at infinite distance away from the sun. Both sides of the
> spacetime equation must equate.

True enough, but again, that's far away. Nearer the gravitating body, you have to use smaller and smaller inertial laboritories to say they are approximately flat or proper spacetimes. It's at the boundaries of these labs you find the small fudges that totalled wind up showing the curvature.

> Not worth bothering!

Well, when you model the spacetime around the sun as deflecting it toward the sun, then at the other side, deflecting away from the sun, if I took your meaning, then it is not worth bothering with the analogy, because instead of a prism, you are using a flat plate. So I'm not interested in going there.

> Hey, according to Schwarzschild metric, the curvature of spacetime

> behaves like a gradient where the severity of the curvature in
> spacetime is stronger as one moves towards the sun

I don't disagree. In fact, this model is interesting as you get very close to a black hole, where the infalling ray becomes perpendicular due the the ratios of the medium... however, again, it is an analogy.

> in any directions.

This sentence end has problems.

As you move closer to the sun. Not in any direction. The more precise way to say it would be to a smaller r in the metric.

> In equal distance away from the sun, the degree of curvature in
> spacetime is the same. So, your excellent analogy of the
> gravitational lens behaves like a prism firmly applies.

Huh..., and I thought you didn't like it.

> A photon will be deflected towards the sun as it travels towards the
> sun. However, the index of refraction reverses as it travels away
> from the sun. Therefore, logically, we should expect the photon to
> undo its bending as it leaves the sun. GR math should shows this, and
> it does.

ut oh. Okay, this is what I thought you were saying and this is where the analogy falls apart.

Light does not approach the gravitating body like it was a plane of glass, first deflecting down on contact with the slower indexed material. Like an accelerated frame (equivalence principle) the light appears to bend

> Well, that explains it. Lacking any mathematical skills himself,
> Einstein had to rely on his creatively freelance style to do so. With
> the ingenious way of zeroing in on a 2nd order effect with only the
> 1st order tools, he was able to place himself among the Hall of Shame
> of the dozen or so predictors of Mercury's orbital anamoly. Remember
> he did that without a complete set of field equations nor the
> Schwarzschild metric.

Having placed himself among the others predicting Mercury's orbital anamoly doesn't seem to bad a thing, since Einstein got it right to high accuracy and without having to bother with any special assumptions of tweaking of constants or variables, etc., but from his original principles unaltered.

Again, Will is an interesting author explaining how Brans Dicke gained prominence, for a time, because that theory had a slightly different smaller effect. However, with better accuracies, GR was found to be the

more correct of the two.

> The no−mass limit is r0 where r0 is the distance of perhilion as if
> the
> sun has zero mass. Taylor's b is not r0. So, do you now agree with
> me?

Sorry, don't even understand you. What is the Taylor reference? EBH? Spacetime Physics? Something else? When did the perhilion come into the discussion?

> You are not making any sense here.

Feeling is mutual. I'm not following your objections.

> From what I have gathered, you are describing the deflected
> distance of the photon at its perihelion which is not defined as the
> impact factor in Taylor's derivation.

Oh! no.

No. The impact parameter is not the distance from r=0 to r="the closest point of approach" of the photon. Or said another way, which I believe now you might be saying, the impact parameter b is not the radius of the peirhelion.

Instead, the photon has an initial "momentum" in some direction. This will not be directly at the gravitating body. If it were we'd not be talking about light passing by, but instead hitting dead center. The impact parameter is the displacement from head on as measured in far away flat space.

So for a ray just grazing the sun, it's impact parameter is basically just a touch more than the diameter of the sun. So this impact parameter is one thing entered into the diff. eq.s describing the motion.

> Are you quoting all these last few paragraphs from a book?

No, if you looked at the book, you'd see I was not. In fact in making this answer, I've been in five different books, comparing their treatments, and trying to distill the simplest answers, without leaving out too much detail.

Perhaps I should have tried more books, to find other approaches. I might. But they all tell the same story, although the particular derivations they use follow different paths.

No, the reason I mentioned MTW pg 673 was they had three different diff. eq. forms, and all of them showed the same two parameters which seem to hold sway on the photon motion. One part is the inital setup, that being the impact parameter, or how close the photon would have passed the

center of the sun, if there was no gravitational field there. The other has to do with the mass of the sun and the photons location relative to it, sometimes called an "effective potential".

>From those two parameters all the motion of the light can be calculated.

> The authors seem to try to make it as confusing as possible.

I'd say instead, the authors try to match the level of understanding of their intended audience, and also the level the dilligent student should have attained upon reaching that point in the book.

The problem with understanding section 25.6 in MTW Orbit of a photon..., is it requires understanding 25.5 Orbits of particles, which ties back to the Schwarzschild geometry, etc.

> So, not able to understand all these, the readers have to move on to
> address the issue of photon deflection. It really does not require
> sophisticated mathematical skills to tell that the text book
> derivation
> of the photon deflection is totally bogus.

Yes, actually it does require sophisticated mathematical skills. From the Schwarzschild geometry, you can get differential equations that describe the motion of particles. MTW, D'INV, etc., start with those equations (See Binet's Eg. http://scienceworld.wolfram.com/physics/BinetsEquation.html) in the relativistic sense, and move on to massless versions, then extract the necessary calculation. If you can't follow those mathematical gymnastics, which they assume their readers are already equiped to do, then pronouncing them bogus is perhaps premature.

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Randy M. Dumse

Caution: Objects in mirror are more confused than they appear.

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