the general science journal

How General Relativity Solves the Metonic Cycle

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The Metonic Cycle has been known since before the time of Homer. Odysseus timed a secret meeting with Penelope at the precise moment of Sun and Moon conjunction. Although the Chaldeans and Babylonians both knew of the cycle, it gets it name from Meton, a Greek astronomer who in 432BC calculated the interval of the cycle to be 19 (Tropical) years with a remainder of 2 hours. The Metonic Cycle describes the time it takes for the Moon and Sun to return to the same positions, relative to the Earth.*

Although astronomers currently accept the Metonic calculations (with some tiny updates) they believe the cycle is just a coincidence. They do not dismiss it as astrology, but they do dismiss it as having no mechanical cause. It is real, but not due to mechanical affects; or so they assume. Wikipedia puts it this way,

This cycle is an approximation of reality. The period of the Moon's orbit around the Earth and the Earth's orbit around the Sun are independent and have no known physical resonance. Examples of a real harmonic lock would be Mercury, with its 3:2 spin-orbit resonance or other orbital resonance.

I will show this is false. The Metonic Cycle is caused by lunar precession caused by General Relativity.** That is, the same curvature that caused Einstein to add 43 seconds of arc per century to the precession of Mercury causes the Moon to precess one full month every 19 years, with a remainder of about 2 hours. Since General Relativity is believed to describe a mechanical cause (geometry is as good as mechanics, or better), the standard model is wrong concerning the Metonic Cycle. It is not a coincidence. It has a mechanical cause that can be derived with simple mathematics. We are currently in possession of all the math and numbers required to solve this problem, but no one has yet applied them. I will do so now.

I have shown elsewhere that the simplest way to solve any problem of General Relativity is to invert the field. Rather than give the curvature to the space, I give the curvature to the size/time field. What allows me to do this is Einstein's postulate of equivalence. Einstein showed the mathematical equivalence of acceleration and gravity: the only difference is a vector reversal. Einstein then showed that equivalence required a curved field, but this is not quite true. Mathematically, a consistent field can also be achieved by reversing the vector "by hand" and following the mechanics in that way. Einstein did not want to pursue this method, since it seemed to imply that physical objects were expanding. He preferred to curve the field. However, mathematically, the two manipulations are equivalent. Einstein's postulate of equivalence states it outright, and I have shown that the two maths get the same numbers. I prefer to reverse the vector since it allows me to achieve the same numbers in about 1/10th the time, with simple math. This mathematical field reversal, used as a simplification of General Relativity, need imply nothing about the actual motions. It is a valid mathematical manipulation only, and it has no necessary physical implications.

Some have not liked my method, preferring to stick to the tensor calculus and the curved field. But these folks are enmeshed in a mathematical contradiction, since they have already embraced the field of Minkowski. The GR field as it exists now contains the math and postulates of Minkowski, including the four-vector field, in which time moves on an imaginary axis that is at a right angle to the other three axes. Minkowski admitted that this was just a clever mathematical trick, one he used to express the field in a more elegant manner. He never tried to defend the reality of time being on an imaginary axis or the reality of time moving at a right angle to x,y,z. The four-vector field has been used because it works, and because it vastly simplifies the manipulations of GR. Well, in the same way, my math vastly simplifies the field once again, by a simple mathematical manipulation. And my manipulation is underwritten by Einstein himself, since it is justified by the postulate of equivalence. The postulate of equivalence not only justifies my vector reversal, it all but begs it. In this way, I beat Minkowski at his own game. I have achieved a greater elegance, and I have done so without an *ad hoc* manipulation like field symmetry. My manipulation is a direct outcome of Einstein's own postulate.

As you will see, the vector reversal immediately flattens out the field, allowing me to dispense with the tensor calculus and all lengthy computations. I have already used my method to solve the perihelion precession of Mercury and the bending of starlight. In both cases I achieved exactly the same number as Einstein for field curvature. After these successes, I looked for other problems to apply my new equations to, and the Metonic Cycle is the first of many I will solve using them.

The method is incredibly simple. We reverse all the acceleration vectors in the problem and then look to the time differential caused by light. Precession caused by curvature is due to this time differential. That is precisely why it is relativistic. Specifically, we let the Sun and Moon accelerate in all directions while light is travelling from one to the other. Since the light travels from Sun to Moon, the Sun's acceleration happens after the light leaves it, so we can ignore the Sun. All we have to look at is the Moon's acceleration while the light is in transit.

The average distance of the Moon from the Sun is 1AU, or 149,600,000km. The time of the Tropical year is 365.242 days. The time of the Draconic year, which measures the Moon relative to the Sun directly, is 346.620 days. The sidereal month is 27.322 days. It takes light 499s to travel 1AU. The Moon's gravity is 1.62m/s^2. It's mean orbital velocity is 1023m/s. It mean orbital distance is 384,400km. That is all we will need to solve.

$s = (1.62\text{m/s}^2)(499\text{s})^2/2 = 199.2\text{km}$
The Moon accelerates that far (in each direction) in 499s.
$\tan\theta = 199{,}200\text{m}/1.496\text{x}10^{11}\text{m}$
$\theta = .27465$ seconds of arc

That is the angle of curvature, given motion in one direction in the field. **And it is an angle to the Sun, since the light is coming from the Sun.** It is only half the total curvature in one orbital plane, since the Moon can accelerate both +x and –x. That is, we have only calculated the distance travelled in one direction, so we only achieve the curvature in that direction. If we want total curvature, we must take the increase in diameter, not only the increase in radius, and this will double our number above. But in the current problem, we do not need total curvature, since we will be comparing our acceleration to the orbital motion, and the orbital motion is in one direction only. At any one moment, the Moon orbits prograde, but not also retrograde, you see. So we don't care about the curvature in the reverse direction. It does not affect the calculation.

To calculate precession from this curvature, we must compare the velocity of the Moon due to this acceleration to the velocity of the Moon due to orbiting the Earth and Sun. To make this comparison, both velocities have to be straight-line velocities. Therefore, we must transform the Moon's orbital velocity, which is an angular velocity, into a tangential velocity, which is a vector. That is done with this equation:

$v_t = \sqrt{(a^2 + 2ar)}$

That is an equation I got from Newton, used before the world forgot about the difference between orbital and tangential velocity (but which is still highly useful).

$a = v^2/r = (1{,}023)^2 / (3.844 \text{ x } 10^8) = .002722\text{m/s}^2$
$v_t = 1{,}446.7 \text{ m/s}$

Now we need a velocity due to acceleration. Since we have taken only half the curvature, we only need half the total acceleration.

$v_a = at/2 = 1.62/4 = .405m/s$

Now we compare the two complete rotations, given the two velocities. If it takes 27.322 days going 1,446.7m/s, then it will take 97,597 days at .405m/s.

$(4.7187 \times 10^6)(.27465 \text{ arc secs}) = 97,597$ days

$\mathbf{P_M = 4850.1}$ **arcsec/yr**

We have just found how much of the Moon's orbit the Moon eats up by accelerating into it. That is what precession is, by the postulate of curvature. Now let us find a number for 19 years.

4850.1 arc sec/yr = 92,152 arcsec/19yr

But we have a remainder of about 2 hours, remember, so we have to make a small correction. That 2-hour gap is found at the end of a period of precession, and is the distance from precise conjunction. Therefore the gap is not defined by precession, but by normal orbital motion. The exact gap is 2.082 hours. At 1023m/s the Moon travels (in a curve) 7,667,600m in 2.082 hours. During that same time, the Earth has moved as well, pulling the Moon with it. At 29,780m/s the Earth travels 223,200,000m in 2.082hr. To solve, we must know where in its orbit the Moon is at Metonic conjunction, since we must know whether its relative motion is with the Earth's motion or against it. It could be either one, and we must know in order to know whether to subtract or add at this point. It turns out that at Metonic conjunction, the Moon is nearer the Sun, so that we must subtract. [But this is only an estimate for use in this paper. A precise calculation requires a bit more rigor in this part than I feel required to do.]

So, in two hours, relative to the Sun, the Moon moves about 223,200,000 – 7,667,600

= 215,530,000m = 297.2 arcsec

We take the difference of those two corrections and subtract them from the 19-year number to get

91,854 arcsec/19yr

Now if we divide one full rotation (1,296,000 arcsec/orbit) by that number, we obtain 14.109. In 19 years, the Moon eats up about 1/14th of its orbit. But as we have seen, in this case "its orbit" means its orbit around the Sun. The Moon is precessing relative to the Sun, since the angle we found initially is an angle to the Sun. This means that we must divide the Tropical year by 14, to continue our calculations.

365.242/14.109 = 25.887 days

The Moon precesses an amount of curvature equivalent to almost 26 days every 19 years. That amount of curvature is relative to the Sun, therefore the curvature is (approximately) on the main orbital path of the Earth. But the Moon does not travel on that path. It travels a path about the Earth which curves much more quickly than the Earth's path. We could do a lot of math to compare the two curves, but a quick analysis shows that 26 days of curvature on one path must equal 26 days of curvature on the other, since Moon takes the two paths simultaneously. Therefore, we apply the 26 days of curvature to the Moon's real path, and so appear to already have a full month by some reckoning. But what reckoning is it?

That is not one month by either the sidereal or lunar reckoning, so we need one more step. What we need here is the Draconic calendar, which is a direct comparison of the Moon and Sun. It is also called the eclipse calendar, since it tells us when the Moon and Sun conjoin. Obviously this is the calendar we need, and the Draconic year is 346.62 days, as I said above. If we divide that into the Tropical year, we get 1.054, and if we divide 14.109 by 1.054, we get 13.386. Now, there are 13.368 Sidereal months in a Tropical year, so we have completed the math. In 19 years, the Moon precesses an amount of curvature equivalent to one full month, returning to its original position relative to both Sun and Earth. [25.9 days x 13.368 = 1 Draconic year, therefore 25.9 days as we found it above is a sort of Draconic month whose background is the Tropical year. My final step allows us to assign the 19-year curvature to the Draconic year directly, so that we obtain the correct number for the Moon relative to the Sun (instead of the Moon relative to the Earth or the Earth relative to the Sun)].

The small margin of error is caused by two things. 1) Using mean values. 2) In the correction of 2 hours, using the speed of the Moon relative to the Earth in one curve to estimate its distance travelled on a different curve (its orbit around the Sun). The two curves aren't equivalent, therefore the distances aren't exactly equal.

We used the Draconic year as a correction, since we needed numbers that compared the Moon and Sun directly. I could have used Draconic numbers from the beginning, but the problem had been defined by Sidereal and Tropical numbers, and those numbers are what most people know. Therefore I have preferred to make the correction at the end, with a single manipulation. Of course I could have also used lunar or synodic numbers, and made other transforms, but the method I used above is the fastest. In conclusion, what we found is that the Moon precesses the equivalent of one full month every 19 years, minus 2 hours, and that this precession can be shown to be caused by the curvature of General Relativity and the time separation supplied us by the absolute speed of light. Since this precession causes one full orbit, relative to both Earth and Sun, the Moon must return to the same spot it occupied 19 years earlier. Although I have used a variant math to simplify the calculations, my math is strictly equivalent numerically and mechanically and axiomatically to that of Einstein. However, I have shown that it is much easier to apply, as well as being much more transparent as a matter of kinematics and dynamics.

I might add here at the end that this is the first time in history that anyone has shown the mechanical cause of the Metonic Cycle. Since the time of Einstein, the world has been in possession of the tools to do so, but the difficulties of the tensor calculus made the solution of such a complex problem too daunting. Even with my simplified math, I needed several pages of equations and commentary. The tensor calculus would have turned this paper into 50-page treatise, like other GR solutions, and made it completely impervious to mechanical explanation or comprehension.

I know that some will not understand how the Moon's precession due to curvature can be so much larger than Mercury's, but these readers simply haven't yet understood Einstein's field. GR, due to its axioms, must take into account two related but basically separate functions. Einstein represents both by curvature. The first is Newton's acceleration, which Einstein expresses by curvature. The second is the time differential, which comes out of SR, and Einstein also expresses this relationship with curvature, since it is not linear once it is imported into the curved field. But only the first curvature disminishes with distance. Only in calculating this first curvature would you expect the Moon to experience less curvature relative to the main field. But using the time differential, you must expect the reverse. In this differential field, curvature increases with distance, for the simple reason that it has more time to curve. Or, the angle of curvature is greater since light bends all along the path. This is why the Moon's curvature is greater than Mercury's, regarding precession. This becomes very clear with my math above. This sort of precession is not a phenomenon of the Newtonian field, which is why Newton couldn't calculate it. It is a phenomenon of the time differential field, which increases with distance. That is why it is relativistic, and why it is added as a vector to the curvature of the Newtonian field. This second curvature is a differential field compared to the first (a rate of change of the first), is much smaller than the first, and increases with distance rather than decreases.

Look at it this way. You could express Newtonian gravity with curvature, ignoring relativity and the time differential completely. Curvature is just a mathematical way of expressing the acceleration, and it need have nothing to do with relativity. Say you accepted Einstein's postulate of equivalence but not SR. Well, in that case you could still set up a Gaussian or Riemannian field to express Newton's accelerations. That is what Einstein did, in fact. It was not SR that forced him to go to the curved field, it was equivalence (he thought). Only afterwards did he import the postulates of SR into GR, bringing into the field the time separation I have used above.

Once he did that, he had a sort of doubly curving field, and it was only that doubly curving field that gave him variations from Newton. Without the second curvature supplied by the time differential, Einstein's curved field would have given him the same numbers as Newton. Everyone should know that, since many of the tensors express only what we would call the Newtonian curvature. It is only the full assortment of tensors that allows one to calculate variations from Newton. Well, the second curvature must increase with distance, as my inverted field makes clear.

Now, admittedly this has not been current wisdom. Most of the biggest names in physics don't currently comprehend how the field works, and once they get beyond the problems Einstein solved himself, they start making false and illogical assumptions. They take the great machine that is the tensor calculus and just throw the main switch. They make no effort to understand the mechanics, since the mechanics is all hidden by the machine.

And this is precisely why none of them has ever used GR to solve this problem of Meton. The machine is so big they do not know how to drive it. I have simplified the equations for this very reason. I knew that I must not only solve the problem, but must do so in a way that was so transparent it defied contradiction. Anyone who wants to dismiss my solution must explain to the world how I got the right answer with such simple math. If I am wrong about the Metonic Cycle, why did my math work so well? If my math is wrong, then how could I get Einstein's numbers for Mercury's perihelion precession and the bending of starlight? If my math is wrong, how is it possible that I have used it not only to match Einstein precisely, but to discover things he could not?

*Obviously, both the Moon and the Sun are in the sky at the same time during this conjunction, which means that the Moon is nearer the Sun than the Earth. This is important later in the calculations, since in that quarter the Moon moves against the Earth's motion.
**This is not the same as normal lunar precession, which measures the Moon's ascending node around the ecliptic and is equal to 18.613 years. The two are related but are not equivalent, as I will show in a subsequent paper.