Emmy Noether, the ignored scientist

Noether's theorem enhances Einstein's Relativity

Introduction and relevance

Emmy Noether (1882 – 1935) was a brilliant mathematician, creating one of the pillars of physics: defining reference frames within which energy and momentum conservation can be proven. However, she was at the wrong place at the wrong time. The best position she could obtain was that of an *assistant* to David Hilbert, a mathematician at the University of Göttingen. In 1933, she fled to the USA, where she died two years later.

In 1915, she was hired by professor Hilbert to the university of Gottingen, who stated that "I do not see that the sex of the candidate is an argument against her admission as lecturer. After all, we are a university, not a bath house". Hilbert did, as one of the very few male scientists, *not ignore* her. In 1918 Noether's theorem was published, a year *after* Einstein published his theory of General Relativity. Unfortunate timing, because her theorem would have helped Einstein with his theory. General Relativity is in some respects in conflict with Noether's theorem. Although she signaled these inconsistencies to Einstein and despite his admiration for her work, he somehow did not take her comments to heart and *ignored* these comments in his work.

Emmy Noether remains the ignored scientist because her theorem is still not implemented in Einstein's theory. Einstein's theory is brilliant, but not perfect. For example, energy conservation requires the speed of light to be invariant to time in the *wider* reference frame, not just in the local reference frame. Because Einstein did not correct his theory for Noether's theorem, a small error lingers in the Schwarzschild solution, which prohibits the Shapiro delay to be explained by the Schwarzschild solution. Amazingly, Noether's theorem is not even mentioned in a major work of Relativity: Misner, Thorne, and Wheeler's "Gravitation". Emmy Noether, the *ignored* scientist.

Implications: 1) Inability to use the Schwarzschild solution to describe the Shapiro delay, 2) Failing proper time in gravitation at high transversal speed (like at CERN), 3) Failing energy-momentum conservation *within* a sphere, 4) Ability to compute escape speed from a sphere, 5) black holes *without* singularity. Let us now look further into Noether's theorem, the resulting error in General Relativity, followed by the repair the Schwarzschild Solution for Noether's theorem.

Noether's theorem of energy and momentum conservation

Noether's theorem is based on symmetries, every symmetry results in the conservation of a physical quantity. The symmetry of space (space being the same everywhere and in all directions) results in the conservation of momentum. The symmetry of time results in the conservation of energy; the laws of physics and its constants like the speed of light "c", the Newton constant "G", and the Hubble constant "H" must remain the same over time to *prove* energy conservation. The symmetry of orientation (the same in all directions) results in the conservation of angular momentum.

However, Einstein's theory of General Relativity conserves energy-momentum within a *local* Lorentzian frame. Considering the second and third order partial derivatives of his theory, we must realize that the outcome is local. When the local frame is limited such that it is Euclidean (also called "local Lorentzian"), energy-momentum is conserved, also according to Noether's theorem. Criticism (by Noether and Hilbert) that Einstein's theory of General Relativity is not

conserving energy-momentum is thus partially correct; energy-momentum is not conserved within the *wider* space-time reference frame.
The authors distinguish energy-momentum conservation within a local Lorentzian frame, from energy-momentum within a wider "Noether frame"; a Noether frame is a Euclidean reference frame within which the laws of physics apply. Within a Noether frame, energy-momentum is conserved, while the constants of nature like "c", "G", and "H" are the same everywhere, the same in all directions, and the same over time.

To unite Einstein's Relativity with Noether's theorem, we need to place Einstein's space-time within a wider hypothetical Noether frame. The wider coordinates, whether in Cartesian or in polar coordinates, are coordinates within a Euclidean (flat and hypothetical) Noether frame. For example, starlight bends around the sun as observed by Eddington in 1919. The starlight goes through space-time, but is curved relative to a wider Euclidean Noether frame (relative to the far stars).

Resulting error in General Relativity, g = –1 withdrawn by Einstein

In 1915, Einstein demanded that the determinant of the covariant metric tensor equaled minus one (g = –1). This demand is in contrast with Noether's theorem demanding *isotropy* in the reference frame. For example, in the Schwarzschild solution, the radial direction (dr) is treated differently from the transversal directions (r.dθ and r.sinθ.dφ). That is not Schwarzschild's error, he made use of Einstein's demand of g = –1 to find his first solution in 1916.

However, Einstein abandoned this demand in his final publication in a single footnote in 1917, after Schwarzschild's death. Amazingly, nobody corrected the Schwarzschild solution for the abandonment of the g = –1 demand, not even Einstein himself. If he had not ignored Noether's criticism, he would have changed this demand into an invariant speed of light "c" in all directions both in the local frame and in the wider reference frame. Emmy Noether, the *ignored* scientist.

Resulting error in the Schwarzschild Solution

In 1922, Eddington wrote his book "The Mathematical Theory of Relativity", in which he describes the solution to a mass-point. He comes to a slightly different outcome than Schwarzschild did in 1916. While Schwarzschild used an intermediate variable "R" to get to his solution ($R^3 = r^3 + R_S^3$, in which "R_S" is the Schwarzschild radius), Eddington used the polar coordinate "r" directly, see the formula (1) on the next page. The direct use of the polar coordinate "r" solves the Noether demand for an invariant speed of light "c" in the radial direction (dr) only.

Amazingly, Eddington unified a variable V(r), by "dropping the suffix". It seems like he wanted his solution to closely match Schwarzschild's solution by unifying V(r). So, Eddington reinstated the invariant speed of light in the radial direction (dr), but did not proceed to do the same for both transversal directions! If he had not ignored Noether, he would have had the key to explain the Shapiro delay. Emmy Noether, the *ignored* scientist.

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Shapiro's experiment

In 1963, Shapiro performed a nearly incredible experiment, sending a radar signal to Venus and back, while Venus is at nearly the other side of the sun. This radar signal takes about half an hour to return. This radar signal is slightly delayed, the "Shapiro delay", a mere 190 microseconds if the signal passes at three times the radius of the sun.
To explain the delay, the Schwarzschild solution of the sun as mass-point would be perfectly reasonable, but Shapiro didn't. Why he didn't, we don't know, although the authors suspect that the failing result is the reason. If the Schwarzschild solution is used, an incorrect delay is obtained!

The delay in the radar signal is not the same over the whole trajectory. The delay is strongest the closer the signal gets to the sun. However, in Eddington's version of the Schwarzschild solution in which he dropped the suffix, the effect is zero closest to the sun! If Eddington had not unified V(r) by "dropping the suffix", he could have explained the Shapiro delay! Shapiro had to go back to Einstein's field equations to solve the delay. Shapiro could have corrected the Schwarzschild solution for Noether's theorem but he did not. Emmy Noether, the *ignored* scientist.

For Specialists: Repairing the Schwarzschild Solution

However, Shapiro was the first to establish the relation between a time difference as measured from far "dt_∞" and the time difference in absence of gravitation "dt" (Euclidean, in which Pythagoras applies): $dt_\infty = dt / \Phi$, in which "Φ" is the gravitational potential, see formula (2). The authors will now use this relation to repair the Schwarzschild Solution for Noether's theorem.

The current Schwarzschild solution as Eddington worked out, needs just two relatively small modifications to adhere to Noether's theorem. These modifications restore an invariant speed of light, and interpret time as Schwarzschild defined time: measured from far or dt_∞, which is usually written as "dt". The solution of Eddington looks like (R_S is the Schwarzschild radius of $2G.M / c^2$):

$c^2.dt_0^2 = c^2.\sigma^2.dt_\infty^2 - dr^2 / \sigma^2 - r^2.(d\theta^2 + \sin^2\theta.d\varphi^2)$	$[m_0^2]$	Eddington's version	(1)
$\sigma^2 = \Phi = 1 - R_S / r$	[ ]	gravitational potential	(2)

Note that "σ" is the square root of the gravitational potential called the "gravitation-factor" see formula (4). The lack of isotropy is found in the transversal terms $r.d\theta$ and $r.\sin\theta.d\varphi$; this is where Eddington unified the term V(r) by "dropping the suffix". The repair includes the term V(r) again by dividing the transversal terms by "σ^2" and use Shapiro's formula for the time difference "dt_∞":

$c^2.dt_0^2 = \{c^2.dt^2 - dr^2 - r^2.(d\theta^2 + \sin^2\theta.d\varphi^2)\} / \sigma^2$	$[m_0^2]$	*repaired* Schwarzschild solution	(3)
$c^2.dt_0^2 = \{c^2.dt^2 - v^2.dt^2\} / \sigma^2$	$[m_0^2]$	based on ds = v.dt	
$dt_0 = dt / \sigma.\gamma$	$[s_0]$	*repaired* Schwarzschild solution	(4)

Formula (4) is the same formula as formula (3), just contracted: $ds^2 = dr^2 + r^2.(d\theta^2 + \sin^2\theta.d\varphi^2)$. Special Relativity reappears in absence of gravitation ($\sigma = 1$), the boost-factor ($c^2 / \gamma^2 = c^2 - v^2$) reappears! Based on energy and momentum conservation, we also get (see book II):

$E = \sigma.\gamma.m_0.c^2$ [J] energy of mass-particle (5)

Note that uniting the Schwarzschild solution with Noether's theorem is also uniting Special Relativity with the (repaired) Schwarzschild solution. Finally, we can now also establish the gravitational potential *inside of a sphere* with radius "R" based on continuity (see book II):

$\Phi = 1 - 1½R_S / R + ½R_S.r^2 / R^3$ [ ] inside gravitational potential (6)

Relevance of the repaired Schwarzschild Solution

This far it is all theory, you may ask yourself what purpose it serves. Apart from the beautiful mathematics and the formula for the *inside* of the sphere, we have real useful applications:

1) the escape speed from any object in space can be accurately established,
2) the temperature of the core of the earth and sun can be computed (in fact the core temperature of any star or planet can be computed!)
3) the cesium clocks on earth can be synchronized better,
4) our theory has no need for singularities as the radius "R" is always larger than R_S.

at 1): Formula (5) can be used to compute the escape speed from a sphere ($\sigma.\gamma = 1.0$),

at 2): Formula (6) for the inside of a sphere is useful to establish the temperature at the core (r = 0) of the earth (> 5,380 K) and the sun (> 15,500,000 K),

at 3): Formula (4) accurately describes the behavior of cesium clocks at different locations and at different rotational speeds on earth,

at 4): Formula (6) limits the radius "R" to at least $1½R_S$, there cannot be a "falling through the event horizon of a black hole", the Schwarzschild radius "R_S" (the so-called "event horizon") is by definition within the real radius "R", there is no "event horizon".

For further details and analyses, see book II "Repairing Schwarzschild's Solution".

Summary

Ignoring Emmy Noether as a brilliant scientist was a loss to the advancement of Relativity. The authors have applied the same method of uniting Einstein's Relativity with Noether's theorem in the Robertson-Walker Solution. This will create a beautiful space-time model, a model which would please Einstein, Minkowski, and Noether alike. This cosmological model, a 3-sphere space-time, is based on Einstein's first model, but with a twist, the four-dimensional radius is equal to time! This model explains the galaxy distribution over the universe, the fast star formation at far galaxies (redshift plus one faster), and has no need for dark energy or a lot of dark matter.

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More information?

Our three books (www.loop-doctor.nl) describe the repair of Einstein's Relativity for Noether's theorem in full detail. We hope you get as many "aha" experiences as we did,

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February, 2018