Raising a question regarding an alternative explanation for the dark matter effect after developing an intuitive model for general relativity

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Abstract

To explain general relativity to the public, often the rubber blanket model is used. However, it can be criticized for again needing gravity and using an additional dimension. Here, employing a mesh-grid of triangles, we develop a model that explains gravity only with the curvature of space inside the twodimensional plane and works without the need for an additional dimension. Based on this model, we review the derivation of Newton's law at the different magnitude scales within our universe while emphasizing the assumption of a flat background space. Finally, we raise the question whether a completely different gravitational law than Newton's could hold for galaxies, which could be derived from Einstein's field equations while abandoning the assumption of flat background space at this magnitude scale. Consequences would be to explain the dark matter effect by operating gravity, to explain the dark energy effect by a net gravitational blueshift of light in the expanding universe and a slightly changed perceiving of the starry sky.

The rubber blanket model

Since we were taking the first steps with general relativity, the rubber blanket model has been applied to explain the curvature of space to the public (**figure 1**). With the rubber blanket model, one understands intuitively two important aspects of general relativity. First, masses curve the space, and the extent of curvature is related to the amount of mass, i.e. more massive objects lead to more curvature than less massive objects. Second, the trajectories of objects is deviated by the curvature of the underlying space.

However, the rubber blanket model has some imperfections for that it can be criticized because they are misleading. The main criticisms are that is again needs gravity to work and that it uses an additional dimension. The masses only dent the rubber blanket because they are pulled down, presumably due to gravitation (**figure 2 A**). Furthermore, the movement of the objects only takes place because the objects are pulled down along curved rubber blanket – likewise presumably due to gravitation. Therefore, the rubber blanket model does not explain gravitation fully by curvature. It still needs the gravitation to function. One idea to overcome this criticism is to use a toy car instead of a marble (**figure 2 B**). Still not illustratin *why* the central mass curves space without gravity, this model at least shows that the toy car follows the curvature of the spacetime - also in case the curvature is the opposite way round (**figure 3 A**). Therefore, it explains the deviation of the trajectory of the car fully by curvature. Why does the toy car move that way? If it went straight, the path close to the central mass, which the left side of the car takes (**figure 3 B, green**), would be a little bit longer than the path further away from the central mass (**figure 3 B, yellow**). Only with the deviated trajectory, both paths of the right and the left side of the car are equally long (**figure 3 C**). And as the internal forces of the toy car keep it rigid and resist the different forces at both sides, a torsional moment is the result and the trajectory of the car is deviated.

For symmetry reasons it's appropriate that the rubber blanket model simplifies the threedimensional space into a twodimensional plane. However, it curves into an additional dimension, while general relativity does not need any additional dimension. It does not help to look at the rubber blanket model from above because the projection of the paraboloid function to the plane would not show any distorted squares. The squares of the rubber blanket model from the perspective of below or above are flat and undistorted (**figure 4**).

A 2-dimesional model of general relativity

To find a model for general relativity which does not need an additional dimension and works in the twodimensional plane, we take a look into the mathematics. The Schwarzschild metric describes the curvature of spacetime mathematically. This is what is underlying the rubber blanket model, it is the paraboloid which is described by the spatial term of the Schwarzschild solution:

$$ds^2 = -\left(1 - \frac{r_S}{r}\right) dt^2 + \frac{1}{1 - \frac{r_S}{r}} dr^2 + r^2 d\Omega \qquad (1)$$

The coefficient of the space-part of the metric is always bigger than 1 and approximates 1 in the infinity (**figure 5 A**). That means that near the central mass there is more space than further away from the central mass. If this coefficient were constantly 1 the space would be flat. The coefficient therefore can be interpreted as the density of space. A graphic visualisation is a mesh-grid of triangles (**figure 5 B, C**). It‘s easy to change the density of the triangles by adding them or taking them away. With squares that doesn‘t work. If there are more triangles as in the centre, the triangles have to become smaller to fit into the image. The curvature of space, however, is visualized through the fact that the triangles actually all have the same area. By looking at this model, one understands intuitively that the curved is spaced and how the curvature of space is realized in nature: That there is more space “pressed” into the plane through curvature. That is a better visualization for the curvature of space than the rubber blanket model as it doesn’t use any additional dimension and educates the contemplator that the curvature takes place *within* the dimension it is happening. That is what the Schwarzschild solution actually describes: that more length is put into the centre than would be expected from the outside, if an outside observer would visually interpolate from his own viewpoint. In the inside, there is more space than without curvature, the coefficient of the spatial part of the metric is bigger than 1. Using the mesh grid as a 2D-model for curvature of space, the trajectories of the objects are diverted in direction of „more space“ – similar to a car with differently big wheels will be diverted in direction to the smaller, more compact, wheel (figure 6).

The coefficient of the space-part and the coefficient of the time-part of the metric are reciprocals (that is true in every spherical symmetric spacetime out of the masses). That means that the time runs slower where there is more space. The action on our car is the same again: The car will be diverted in direction of a slower moving wheel, in direction to the centre of mass. Finally, the model is a relatively simple one: the mesh-grid of triangles that shows that in the centre there is more space. That only visualizes that the coefficient of the space-part of the Schwarzschild-solution is with mass bigger than one and the larger the mass the larger the curvature. Additionally, one has to memorize that the time is running slower where there is more space. And that objects are moving in direction to more compact space and slower time.

More space with more mass

With the model in figure 6, a new interpretation of general relativity becomes obvious: As there is more space with more mass, mass is surrounded by space like its own field. *That* is the reason why mass curves space, like an electron curves the electric field of a capacitor: because it adds its own field to the pre-existing one. That follows directly from the fact that the curvature of space takes not place in an extra-dimension.

Flat background space and Newton’s law

Until now, most of the models make the assumption of flat background space. This flat background space is only slightly curved by the effects of general relativity. That is visible with the rubber blanket model (figure 1): It‘s a flat rubber blanket, slightly dented by the masses. It‘s also visible in the equations (eq. 1, figure 5 A): The coefficient of the space-part of the Schwarzschild metric is approaching 1 in the infinity. That shows that the Schwarzschild metric assumes that the background space is flat. From the Schwarzschild metric, Newton`s law can be derived, which is well-confirmed within the solar system.

Deviations from Newton’s law

Deviations from Newton’s law within the solar system appear only near the central mass (precession of the perihelion of mercury). At larger scales, however, there is again a deviation from Newton`s law: We measure higher velocities than expected, for example in the rotation curves of the galaxies. To save Newton`s law for galaxies, around 1960, dark matter was postulated that couldn‘t have been found until today. All systems where Newtons law could be confirmed are located in the sphere of influence of a much more compact and far away system: The centre of our milky way. It is that compact and that far away that we do not measure differences in space-time curvature from it within our solar system (no tidal forces). The background space therefore is flat within our moving solar system (figure 7).

Large scales, question for another gravitational law and consequences

At very large scales the universe is quite homogeneous (**figure 8 A**). The single galaxies do not move within the sphere of influence of other more massive and more compact sources of gravity. From that viewpoint and with the insight in mind that mass adds space like its own field, I want to raise the question whether it could be possible that a totally different gravitational law than Newton‘s applies for galaxies, which may be derived from Einstein‘s field equations without the assumption of a flat background space (**figure 8 B**).

The dark matter effect would be explainable without postulating unknown particles. The empty space between the galaxies would be thinner space with faster-running time. Light would undergo a net gravitational blueshift while running through those regions of thin space as the space as a whole is expanding. That possibly could explain the dark energy effect.

No consequences for climate change. That‘s a problem we have to deal with on earth. Fast.

FIGURES

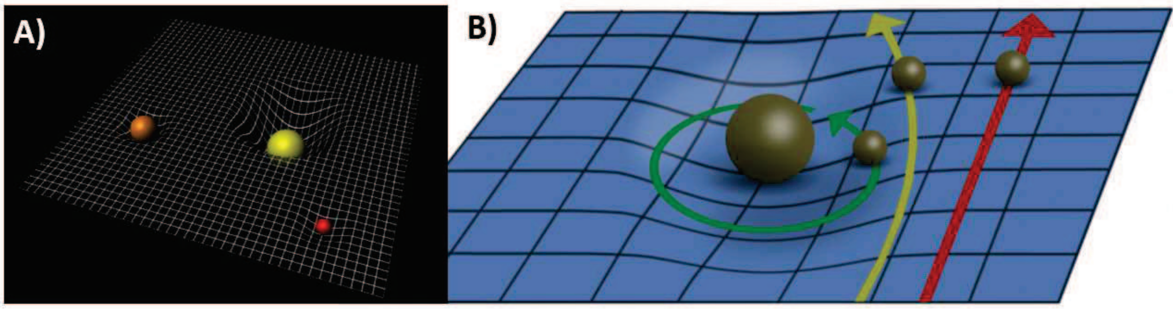

Figure 1. The rubber blanket model is used to explain the curvature of space to the public. It is used to explain that **A)** masses curve the space and that **B)** the movement of masses follows the curvature of space. (Bildquellen: Uni Hamburg, Helmut Linde)

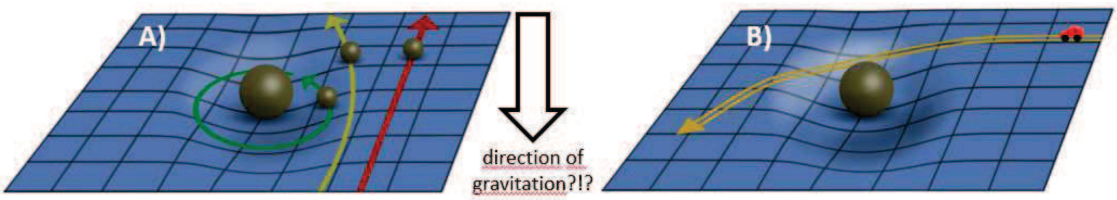

Figure 2. **A)** The masses only dent the rubber blanket and follow the curvature of space with their trajectories because they are pulled down, presumably due to gravitation. **B)** one idea to overcome this criticism is to use a toy car instead of a marble as moving object. (Bildquellen: Helmut Linde)

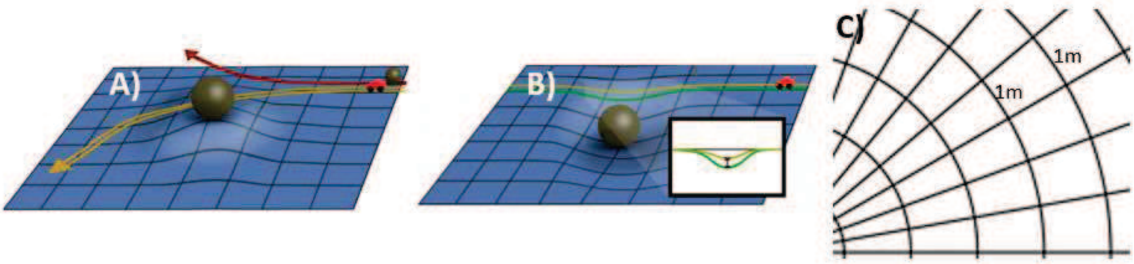

Figure 3. **A)** The toy car also follows the curvature if the curvature is the opposite and the marble would roll down. **B)** If it went straight, the path close to the central mass, which the left side of the car takes (green), would be a little bit longer than the path further away from the central mass (yellow). **C)** Only with the deviated trajectory, both paths of the right and the left side of the car are equally long. (Bildquellen A + B: Helmut Linde)

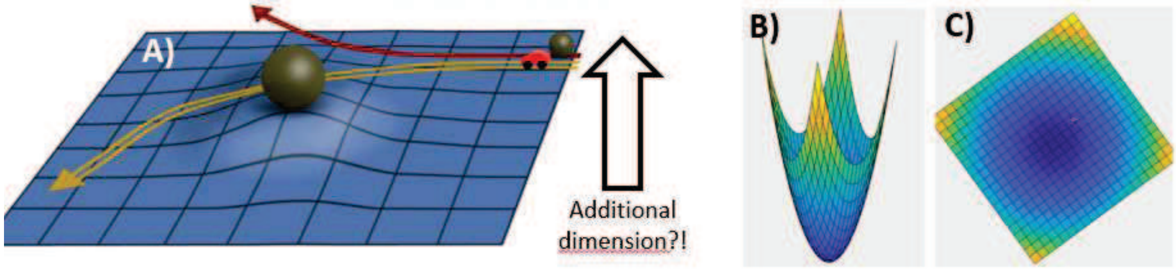

Figure 4. A) The rubber blanket model curves the space into an additional dimension, while general relativity does not need any additional dimension. **B)** Looking at the paraboloid (the mathematical object behind the rubber blanket model) from the perspective above or below does not help: **C)** The projection of the function onto the flat plane is only the flat space and doesn‘t show any distortion.

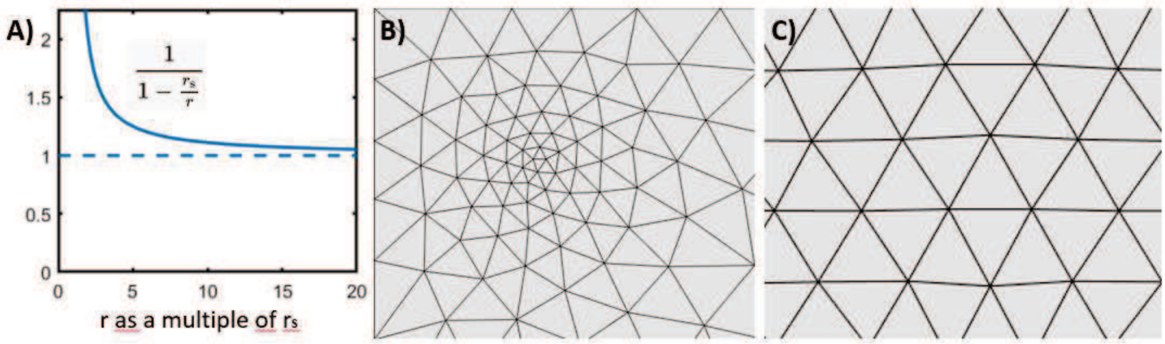

Figure 5. A) The coefficient of the spatial part of the Schwarzschild metric. It is always bigger than one and approaching 1 in the infinity. **B)** A graphic visualisation of the curvature of space in the two-dimensional plane is this mesh-grid of triangles. It‘s easy to change the density of the triangles by adding them or taking them away to create Schwarzschild-like curved space or **C)** flat space. All triangles, especially all those in **B)** *actually* have the same area: That way they are visualising the changing density of space and the curvature of space *within the plane*.

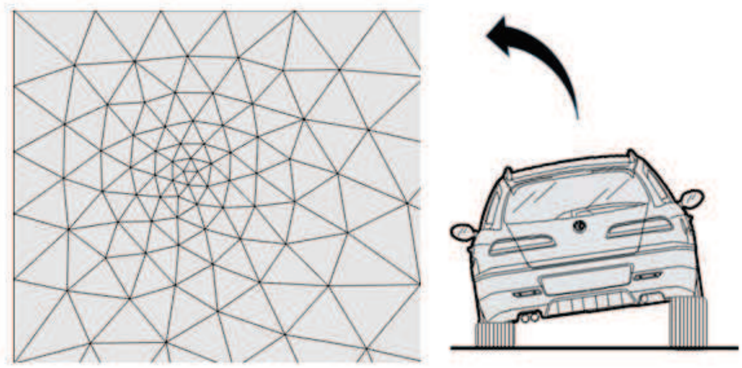

Figure 6. Using the mesh grid as a 2D-model for curvature of space, the trajectories of the objects are diverted in direction of “more space” – similar to a car with differently big wheels will be diverted in direction to the smaller (more compact) wheel.

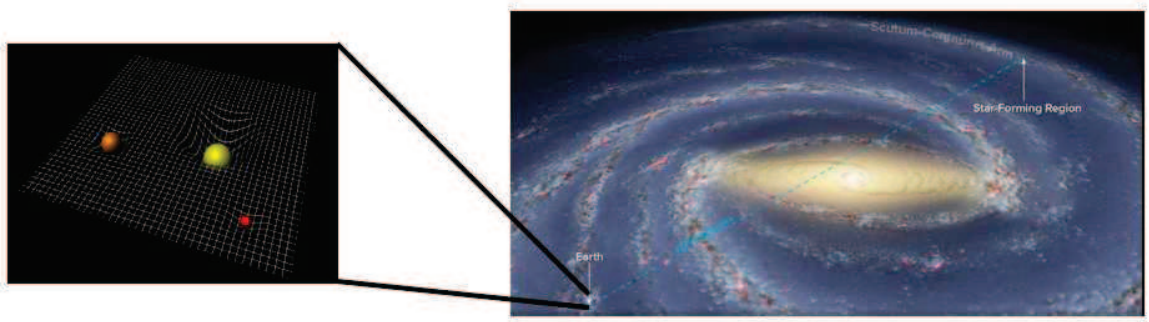

Figure 7. All systems where Newtons law could be confirmed are located in the sphere of influence of a much more compact and far away system: The centre of our milky way. It is that compact and that far away that we do not measure differences in space-time curvature from it within our solar system (no tidal forces). The background space therefore **is indeed** flat in the detection limit within our moving solar system.

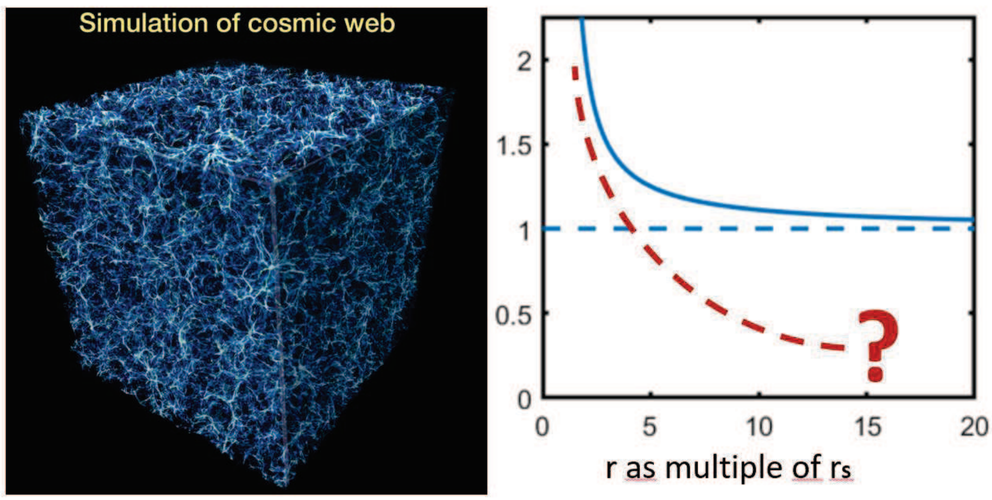

Figure 8. A) Matter distribution in a cubic section of the universe. The blue fiber structures represent the matter and the empty regions in between represent the cosmic voids. (source: https://en.wikipedia.org/wiki/Void_(astronomy)) **B)** I want to raise the question, whether a totally different gravitational law than Newton’s could apply for galaxies, which may be derived from Einstein‘s field equations by abandoning the assumption of a flat background space.

References.

Image of marbles within the rubber blanket: https://hsweb.hs.uni-hamburg.de/projects/star-formation/talks/RAUMZEIT-FHS-banerjee.pdf

Helmut Lindes page regarding the rubber blanket model (german) with the figure 1B, 2A,B, 3A,B, 4A:

https://www.golem.de/news/kosmologie-die-raumzeit-ist-kein-gummituch-2201-162209-4.html

SienceClic: https://www.youtube.com/watch?v=wrwglJjBUYVc

Mesh generator: http://persson.berkeley.edu/distmesh/funcref.html

Paraboloid: matlab standard function (rotate3D)

https://de.wikipedia.org/wiki/Datei:Galaxy_rotation_under_the_influence_of_dark_matter.ogv

https://www.spiegel.de/wissenschaft/weltall/milchstrasse-forscher-vermessen-unsere-heimatgalaxie-a-1172613.html

https://en.wikipedia.org/wiki/Void_(astronomy)