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# A Simple Formula that allows to Calculate the Curvature of the Trajectory in the Minkowsky Space-Time of a Point Located at a Fixed Distance from a Point Mass

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## Abstract

**A formula that allows calculating the curvature of the trajectory in the Minkowski space-time (scalar curvature) of a point in the case of a gravitational field caused by a point mass, through the values of mass and spatial distance.**

***Keywords: Cosmology; General relativity; Curvature of space-time***

## Introduction

Starting from a point mass "M" we study the curvature of the trajectory in the Minkowski space-time (scalar curvature) of a point away from the mass “M” a distance "r".

## Training the Formula

According to rational mechanics, the centrifugal acceleration to which a mobile is subjected that travels around a curve at a speed "v" in a trajectory with a radius of gyration R, is given by:

$$a = -v^2 / R$$

According to the general theory of relativity, the gravitational field is created due to our motion in curved space-time, just like centrifugal force when we are traveling in a car around a curve. If, as we know, space-time moves at a speed of module "c", an observer who is at rest near a mass will be subjected to a gravitational field created by that mass "M", a field that curves space-time, and will experience, due to the speed "c" of space-time and the curvature of space-time, a centrifugal acceleration "a" given by:

$$a = c^2 / R$$

where R is the radius of curvature of the path of that point in space-time. The force to which it is subjected is given by

$$F = mc^2 / R \qquad (1)$$

This force to which it is subjected is experienced as a gravitational force and according to Newton's theory of gravitation it is also expressed as

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$$F = -GM \times m / r^2 \qquad (2)$$

where G is the universal gravitational constant.

Equating the two expressions (1), (2) we obtain:

$$1/R = -GM / \left(r^2 c^2\right)$$

1/R turns out to be the index of the scalar curvature (curvature of the Minkowski space-time trajectory) from a fixed point at a distance "r" from a point mass M.

A formula that allows us to calculate the scalar curvature of the trajectory in space-time of a point, at a spatial distance "r" from a point mass "M", based on parameters that are easy to determine, such as mass and spatial distance. **FIG. 1**

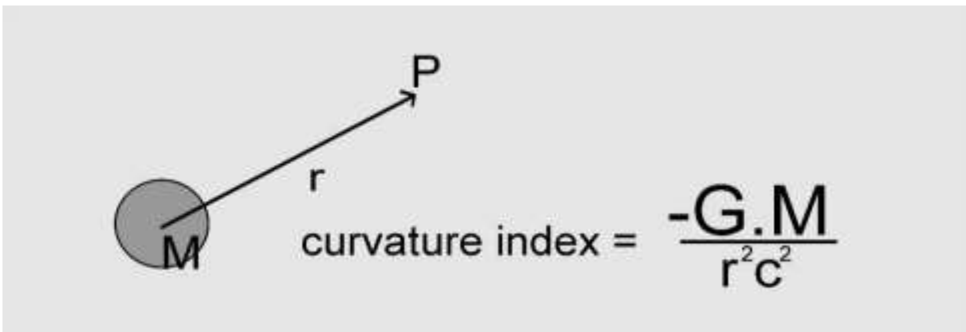


FIG. 1. **Index of the scalar curvature of the trajectory of the point P in the space-time as the function of the values of the mass m and the spatial distance r.**

## A Calculation with Imagination

We are going to calculate the curvature of space-time at the radius of the observable universe and with a mass equal to the total mass of the universe. Let's see the result:

Radius of the observable universe $4.40 \times 10^{26} m$ [1].

Mass of the universe $9.27 \times 10^{52} Kg$

G constant of universal gravitation $6.67 \times 10^{-11} \, Nm^2 / Kg^2$

$$1/R = -GM / \left(r^2 c^2\right) = 6,67 \times 10^{-11} \times 9,27 \times 10^{52} / \left(19,36 \times 10^{52} \times 9 \times 10^{16}\right) = -0,35 \times 10^{-27} \, m^{-1}$$

Value close in order of magnitude to that of the vacuum energy density $0.6 \times 10^{-26} Kg / m^3$ [2].

## Conclusions

For an assumption of a point mass, a simple formula has been obtained that allows calculating the index of the scalar curvature (curvature of trajectory in the Minkowski space-time) of the point (t, r), where r is the spatial distance to the mass "M" that is causing that curvature, depending on that distance and the value of that mass.

## REFERENCES

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