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English CPH E-Book

Theory of CPH

Section Eleven

Color Charges Curve Space

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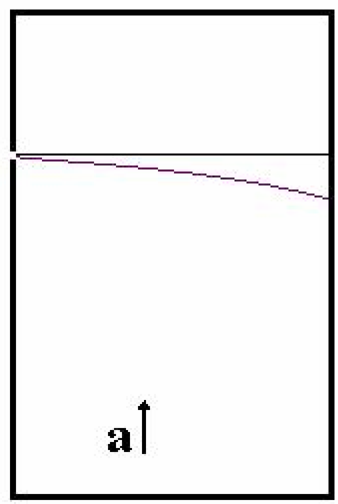
Introduction

The **Einstein field equation** or **Einstein equation** is a dynamical equation which describes how matter and energy change the geometry of space-time, this curved geometry being interpreted as the gravitational field of the matter source. The motion of objects (with a mass much smaller than the matter source) in this gravitational field is described very accurately by the geodesic equation.



Path of light is curvature in a gravitational field and in an accelerating frame

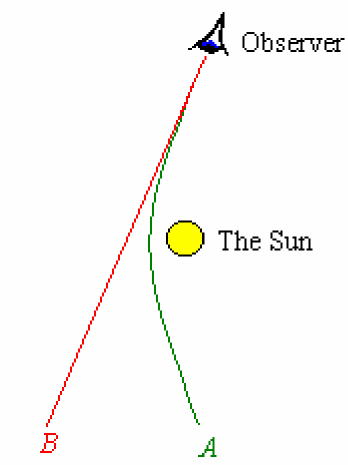
The acceleration of gravity = g = -a = intensity of gravity field.

This theory, referred to as the **General Theory of Relativity**, proposed that matter causes space to curve.

Bending of star light

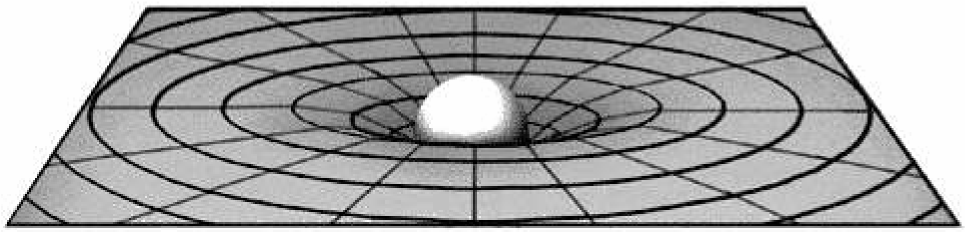
The first experiment to gain public acclaim was the bending of light from distant stars by the sun. Even Newton himself suggested that light may have mass and be bent by a gravitational field, so that light from a distant star would be turned slightly from its straight line path as it passed the sun.

As luck would have it an eclipse did happen on May 29 1919. Two expeditions were sent by the Royal Society and the Royal Astronomical Society to two different places on the line of totality to minimize the risk due to bad weather. Dr. A. C. D. Crommelin and Mr. C. Davidson went to Sobral in northern Brazil, and Prof. A. S. Eddington and Mr. E. T. Cottingham went to the island of Principe in the Gulf of Guinea, West Africa. Test plates were taken to check that none of the instruments had deformed during their travels and the Sobral team stayed in Brazil for a further two months to photograph the Hyades with the same apparatus without the presence of the sun.



The mathematics of general relativity

Due to the expectation that space-time is curved; a type of non-Euclidean geometry is called Riemannian geometry must be used. In essence, space-time does not adhere to the "common sense" rules of Euclidean geometry, but instead objects that were initially traveling in parallel paths through space-time (meaning that their velocities do not differ to first order in their separation) come to travel in a non-parallel fashion. This effect is called geodesic deviation, and it is used in general relativity as an alternative to gravity.



The requirements of the mathematics of general relativity are further modified by the other principles. Local Lorentz Invariance requires that the manifolds described in GR be 4-dimensional and Lorentzian instead of Riemannian. In addition, the principle of general covariance forces that math to be expressed using tensor calculus. Tensor calculus permits a manifold as mapped with a coordinate system to be equipped with a metric tensor of space-time which describes the incremental (space-time) intervals between coordinates from which both the geodesic equations of motion and the curvature tensor of the space-time can be ascertained.

Einstein Field equations EFE

Einstein's field equation (EFE) is usually written in the form:

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi\frac{G}{c^4}T_{\mu\nu}$$

Where

$R_{\mu\nu}$ is the Ricci curvature tensor
R is the Ricci scalar (the tensor contraction of the Ricci tensor)
$g_{\mu\nu}$ is a (symmetric 4 x 4) metric tensor
Λ is the Cosmological constant
G is the Gravitational constant
c is the speed of light in free space
$T_{\mu\nu}$ is the energy-momentum stress tensor of matter

The EFE equation is a tensor equation relating a set of symmetric 4 x 4 tensors. It is written here in terms of components. Each tensor has 10 independent components. Given the freedom of choice of the four space-time coordinates, the independent equations reduce to 6 in number.

The EFE is understood to be an equation for the metric tensor $g_{\mu\nu}$ (given a specified distribution of matter and energy in the form of a stress-energy tensor). Despite the simple appearance of the equation it is, in fact, quite complicated. This is because both the Ricci tensor and Ricci scalar depend on the metric in a complicated nonlinear manner.

One can write the EFE in a more compact form by defining the Einstein tensor

$$G_{\mu\nu} = R_{\mu\nu} + (\Lambda - \frac{1}{2}R)g_{\mu\nu}$$

That is a symmetric second-rank tensor that is a function of the metric. Working in geometrized units where $G = c = 1$, the EFE can then be written as

$$G_{\mu\nu} = 8\pi T_{\mu\nu}$$

The expression on the left represents the curvature of space-time as determined by the metric and the expression on the right represents the matter/energy content of space-time. The EFE can then be interpreted as a set of equations dictating how the curvature of space-time is related to the matter/energy content of the universe.

These equations, together with the geodesic equation, form the core of the mathematical formulation of General Relativity.

Conservation of energy and momentum

An important consequence of the EFE is the local conservation of energy and momentum; this result arises by using the differential Bianchi identity to obtain

$$\nabla_b G^{\mu\nu} = G^{\mu\nu}{}_{;b} = 0$$

This, by using the EFE, results in

$$\nabla_b T^{\mu\nu} = T^{\mu\nu}{}_{;b} = 0$$

This expresses the local conservation law referred to above.

The EFE are a set of 10 coupled elliptic-hyperbolic nonlinear partial differential equations for the metric components. This nonlinear feature of the dynamical equations distinguishes general relativity from other physical theories.

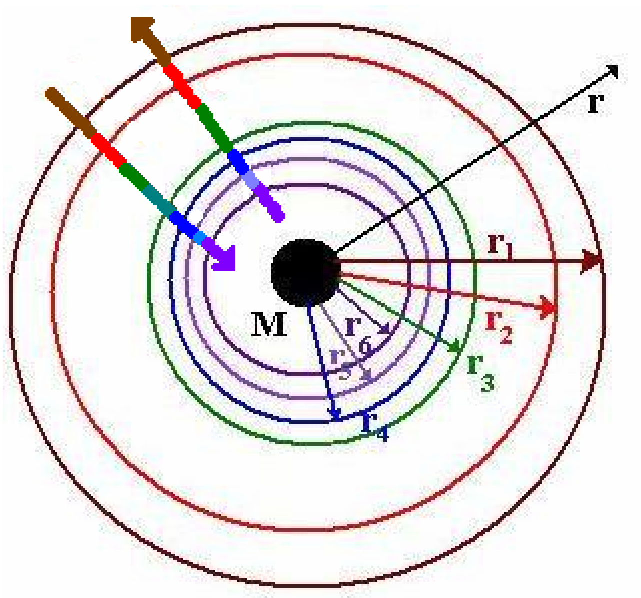
Notices;

Einstein tried to propounding geormtical structure of space by mathematical equations. So, he used non-Euclidian geormetry. There are three considerable notation about Einstein’s equations;

1- Einstein Field Equations not come up of equavalence principle directly. These equations are simly equations that are suitable with general relativity.
2- There is any phisical explain about path of light in gravitational field. Although expalining of frames reffeence are physical conception, but there is not any explain how gravitatinal field effects on photons.
3- Space-time is a continiously quantity in general ralativity. But changing of photon frequency and producing of energy is quantized.

So, I will try explain curvature of space according the structure of photon.

The same potential surfaces;
Suppose there is a field in a chosen space with a property. For example; there is a heater in the room. It makes a thermo field. All point with the same temperature makes a same thermo field surface in the room.
Also, in a gravitational field, all points with the same gravity potential make a same gravity potential surface in space. See following picture.

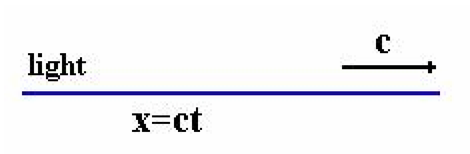


Suppose body with mass M is a sphere body. According the;

$$g=GM/r^2$$

Every point on the red sphere (that shows by circle in picture) has the same potential, other points with the same color makes other same potential gravity. When a photon falls in gravitational field goes of gravity potential to other gravity potential. So, energy (and frequency) of photon depends to gravity potential in its path.
As explained in foregone sections, when photon falls in gravitational field, color-charges enter into its structure, and photon shifts to blue. And when photon escapes of gravitational field, color-charges leave photon's structure, and photon shifts to red (see above picture).
Now let's see how we can explain curve of space according CPH Theory.

Curvature of space and CPH Theory
Suppose a photon is moving in space without gravity effect. It is traveling on linear path.



Inertia observer seems a photon's path without effective of gravity

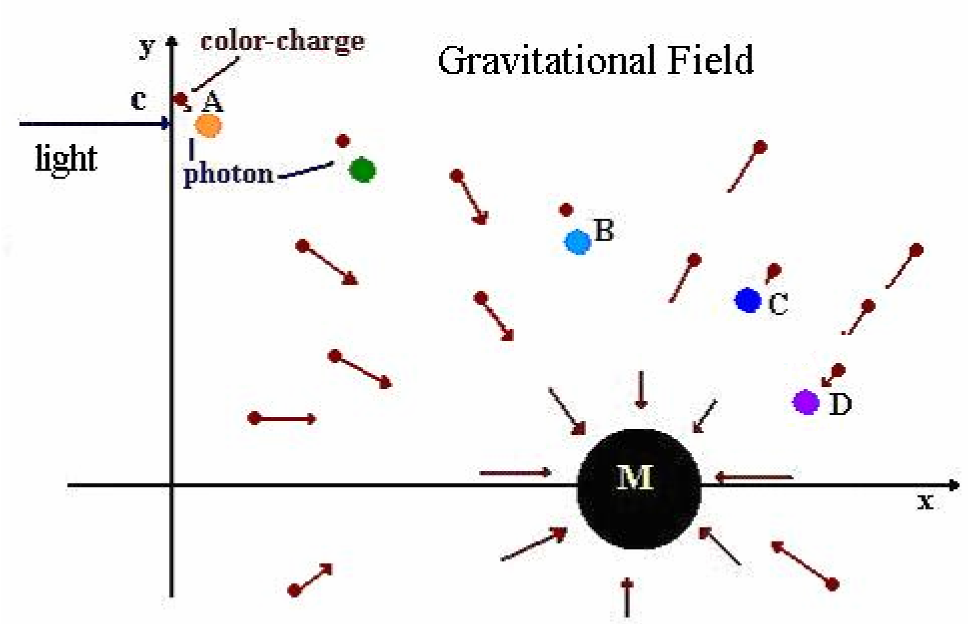
Although there is not any space without gravity effect, but there are many spaces with inconsiderable gravity effect. Now this light ray enters to gravitational field. Photon has mass because it behaves like a mass in gravitational field. Photon has energy and momentum as;

energy $E=h\nu=mc^2=\frac{hc}{\lambda}$

momentum $p=\frac{h}{\lambda}$

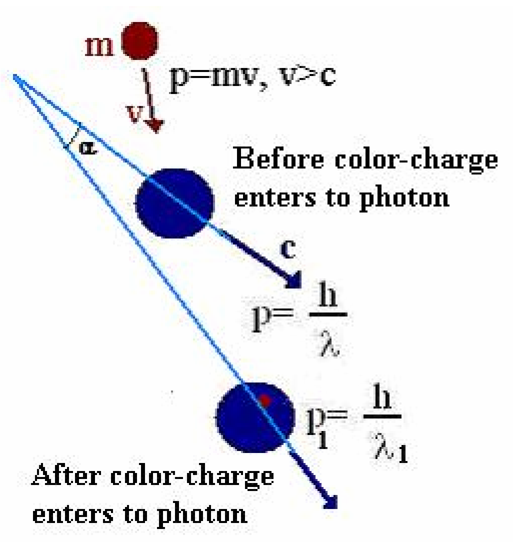
where h is Plank constant and λ is wavelength

Without gravity effect all of above amounts do not change. But in gravitational field they do change. They depend to intensity of gravitational field and do change of a potential gravity surface to another.
According CPH Theory gravity field is formed of color-charges. Those color-charges inter and exit of photon's structure. Also, color-charge has momentum and kinetic energy, and when color-charge enters into photon structure the momentum and energy of photon increases, that is explainable by De Broglie wavelength. Also, changing of photon's momentum depends to force that applied on it. So, according the momentum and direction of color-charge we can find the direction of photon's path (following picture).

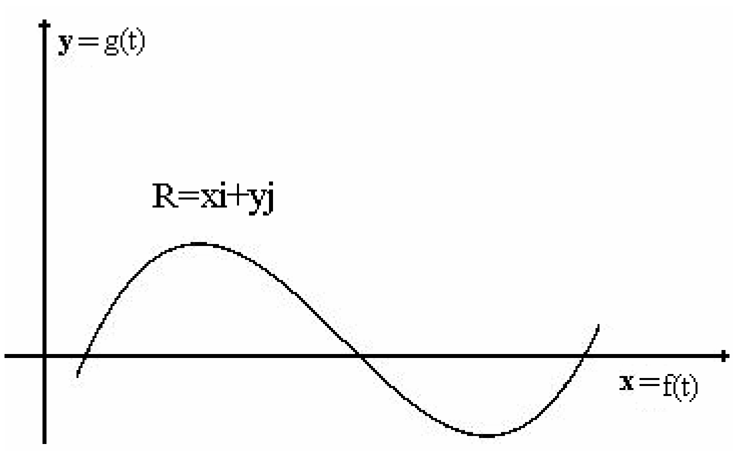


When photon enters into gravitational field, color-charges do effect on it. Color-charges move in direction toward the mass M. According the situation of photon and direction of color-charges, we can find the new photon's situation and its direction.
At point A, photon interacts with the first color-charge. Before of interact photon moves in direction as x axis. And color-charge's direction is toward the M. in this point photon's path changes and does swerve toward the vertical axis. Its direction does change and the path of it doing to curvature.

Interaction photon and color-charge
Look at interaction between a photon and a color-charge. Attend to their directions following picture).



After color-charge enters to structure of photon, a new photon with new energy and momentum appears that is moving on new direction. Do consider that in during interaction all conservation laws keep. According this looking we are able explain why and how the path of light is curvature in gravitational field.
Now we can reconsider to path of photon in two dimensions on x and y axis. Suppose a particle is moving in plane.



x and y are function of other parameter like t

So, curvature of a curve on any point comes of following relation;

$$K = \frac{|\dot{x}\ddot{y} - \dot{y}\ddot{x}|}{[\dot{x}^2 + \dot{y}^2]^{\frac{3}{2}}}$$

K is curvature of curve

$\dot{x}, \ddot{x}, \dot{y}, \ddot{y}$ are the first and second differentials of x and y

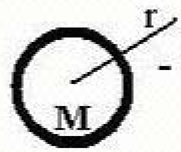
We can look on path of light in gravitational field as a cure in x, y plane and calculate its curvature, but it is not so simply work.

Problems of Calculate space Curvature
There 3 problems for finding the space curvature;
1- Time is not absolute. Also, function of path that depends to time and time depends to gravity potential. In general relativity gravity potential affects on time. For example; clock on the surface of earth doing slow relative a clock in high h. its shows by;

$$T_A = (1 - \frac{\Delta U}{c^2}) T_B$$

T_A on the earth and T_B at high h relative the earth

$$U = -\frac{GM}{R}$$



$$-\frac{GM}{r}$$

$$\Delta U = U_2 - U_1 = -[-\frac{GM}{r_2} - (-\frac{GM}{r_1})] = \frac{GM}{r_2} - \frac{GM}{r_1}$$

So, in during photon is falling in gravitational field, the time is changing in its path. And we cannot use following relation like in an inertial frame.

$$ct$$

2- In relation;

$$T_A = (1 - \frac{\Delta U}{c^2}) T_B$$

According distance is changing, T_B relatives to r, so path relation depends to r too.
3- Direction of photon's moving does change of a point to another point. So, we have;

$$x = f(t, r, \theta) , y = g(t, r, \theta)$$

These show photon's motion in plane is an acceleration motion on two x and y axis.
We can attend to intensity of gravity as:

$$g = GM/r^2$$

But we should separate the gravity accelerates on x axis and y axis. Gravity (gravity force) is an inherent property of space. And Time depends to gravity. So, real function space has five dimensions;

$$(x, y, z, f, t)$$

But in this special case, we attend to a plane ant relation is same as:

$$(x, y, f, t)$$

Space is quantized

What is space really?

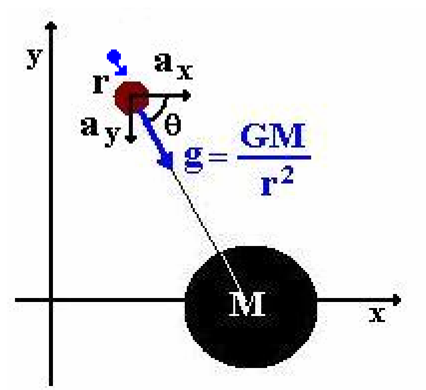
How can answer it without any effect of matter in space?

Path of photon is continuously, but energy is quantized. Space without energy is not a real conception.

In theoretical physics we are studying objects/particles behavior an interaction between them. And space is full of them. Any conception of space depends to our thinking about matter. Matter is quantized. So, real space is quantized too.

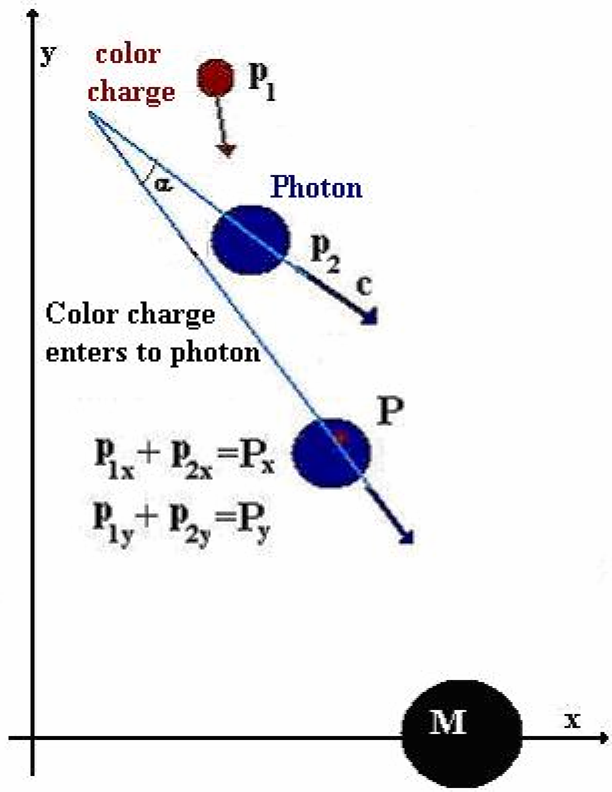
Light equations in gravitational field

Do consider to photon interacts with color-charge in gravitational field. Color-charges with their momentums enter into photon structure, and the photon momentum changes (following picture).



When color-charge enters to photon, energy and momentum of photon change. But momentum is a vector quantity. So, the momentum changes on two x and y axis.

In during color-charge is entering into photon, the set of photon and color-charge has acceleration. And it depends to intensity of gravity in space.



According above picture and momentum changing we can write relations.
Suppose a photon with mass and momentum P_1, m_1 interacts with n color-charges with mass and momentum of p_i, m, and their mass are same and momentum is not same.

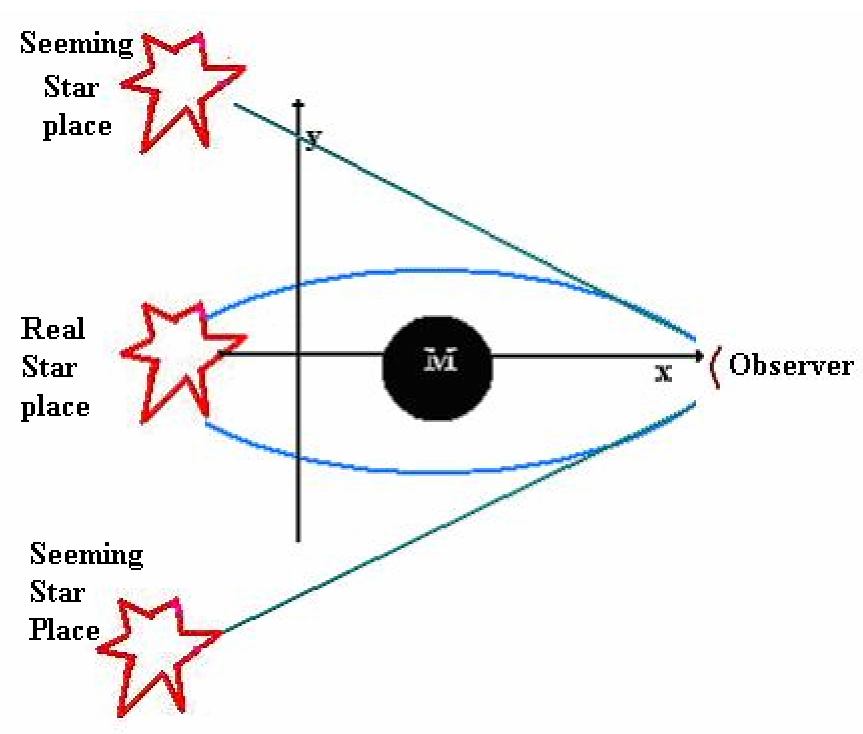
$$\sum_{i=1}^{i=n} P_{ix} + P_{1x} = P_x$$

$$\sum_{i=1}^{i=n} P_{iy} + P_{1y} = P_y$$

$$\sum_{i=1}^{i=n} m_i + m_1 = m_2$$

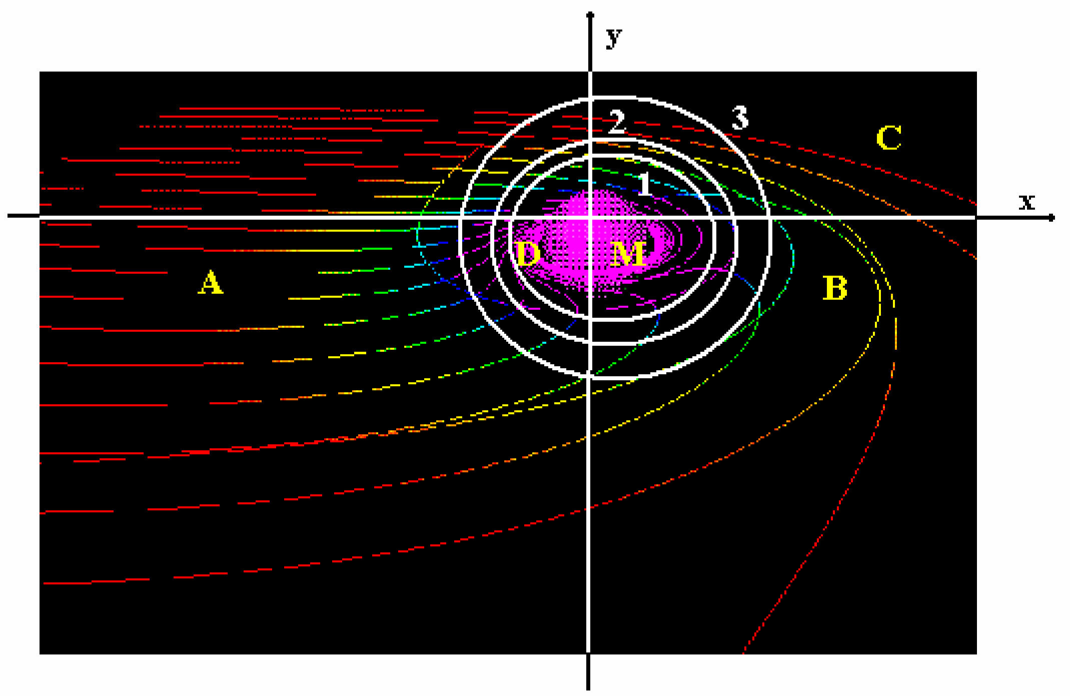
$$m_2 - m_1 = \frac{E_2 - E_1}{c^2} = \text{n}m$$

As above relations show, photon momentum do change on two x y axis. Let's select x axis between source and observer (following picture).



Interaction between photon and color charges causes that the path of photon converts of linear to curvature. Changing momentum on x axis is considerable to understand much important conception about great bodies.

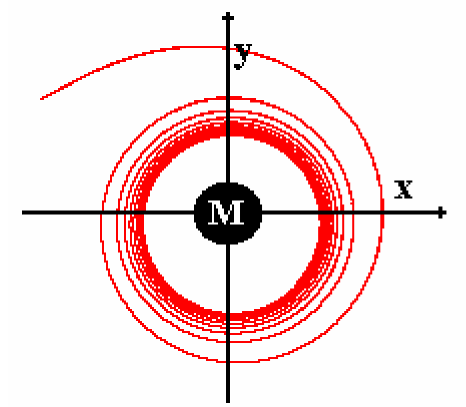
Path of light in strongly gravitational field



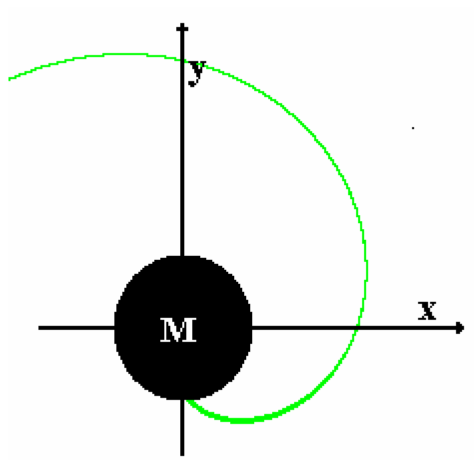
A few areas are considerable in picture

- **A.** Light cannot escape of gravity field. But their momentum on x axis does not let photon falls in body.
- **B.** Some rays escape of some rays move around body. It depends to their momentum on x axis.
- **C.** In this area rays are moving on a curve path.

In totally attend to momentum of color-charges is very important.



Do compare with moon around the earth



Photon falls speedy

Calculation curvature of space

Let's return to curvature of space again. Remember;

$$\kappa = \frac{|\dot{x}\ddot{y} - \dot{y}\ddot{x}|}{[\dot{x}^2+\dot{y}^2]^{\frac{3}{2}}}$$

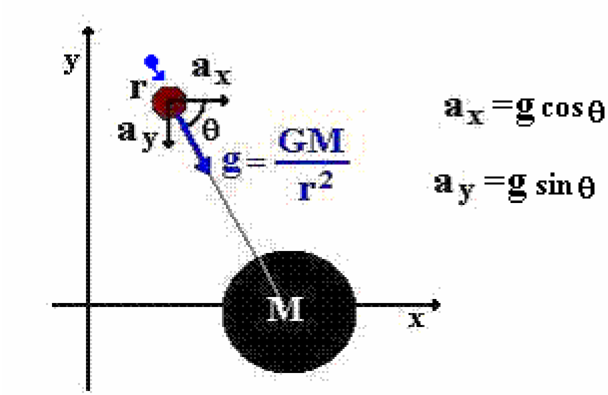
κ is curvature of curve

$\dot{x}, \ddot{x}, \dot{y}, \ddot{y}$ are the first and second differentials of x and y

According to changing of momentum on x and y axis, we should consider to acceleration on these axis. So;

$\dot{x}$ acceleration on x axis
$\ddot{x}$ velocity on x axis
$\dot{y}$ acceleration on y axis
$\ddot{y}$ velocity on y axis

So, we can calculate velocity by integral on accelerations.



But acceleration depends to three parameters;

(r, θ , t) and

$$\ddot{x} = a_x = g\cos\theta$$

$$\ddot{y} = a_y = g\sin\theta$$

But by consider to momentum we are able reach to results simply than path.

$$\sum_{i=1}^{i=n} p_{ix} + P_{1x} = P_x$$

$$\sum_{i=1}^{i=n} p_{iy} + P_{1y} = P_y$$

If we have intensity of gravity or do suppose for bodies, and with comparing with earth or sun, many universal phenomenon are predictable.

So, attention to intensity of gravity and relative it to density of color-charge is helpful.