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Inertial Field

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ABSTRACT: This article aims to demonstrate the existence of a new energy field, here called inertial field, that interacts with the gravitational field in the same way the magnetic field interacts with the electric field. The equations of field, flux, charge, current, potential etc. of this inertial field will be created in the same format as the electromagnetic equations to use the same mathematical tools we use in electromagnetism.

KEYWORDS: inertial field, inertial charge, inertial current, inertial potential.

Contents

1 Symbology

In this text we will use the following symbols with its abbreviated unit of measurements:

N = Newton, kg = kilogram, m = meter, s = second, V = Volt, C = Coulomb, A = Ampere, Wb = Weber, rad = radian.

E = Electric field intensity [$N\ C^{-1}$] [$V\ m^{-1}$];
D = Surface density of electric charge [$C\ m^{-2}$];
V_E = Electric potential [V] [$Wb\ s^{-1}$];
Φ_E = Electric flux [$N\ m^2\ C^{-1}$] [V m];
q_E = Electric charge [C];
I_E = Electric current [$C\ s^{-1}$] [A];
J_E = Surface density of electric current [$A\ m^{-2}$] [$C\ s^{-1}\ m^{-2}$];
ε_0 = Vacuum electric permittivity [$C^2\ N^{-1}\ m^{-2}$] [$C\ V^{-1}\ m^{-1}$];
k_E = Electrostatic constant [$N\ m^2\ C^{-2}$] [$m^3\ C^{-1}\ s^{-2}$];
H = Magnetic field intensity [$N\ Wb^{-1}$] [$A\ m^{-1}$];
B = Surface density of magnetic charge [$Wb\ m^{-2}$];
V_M = Magnetic potential [A] [$C\ s^{-1}$];

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Φ_M = Magnetic flux [N m^2 Wb^{-1}] [A m];
q_M = Magnetic charge [Wb];
I_M = Magnetic current [Wb s^{-1}] [V];
J_M = Surface density of magnetic current [V m^{-2}] [Wb s^{-1} m^{-2}];
μ_0 = Vacuum magnetic permeability [Wb^2 N^{-1} m^{-2}] [Wb A^{-1} m^{-1}];
G = Gravitational field intensity [N kg^{-1}] [m s^{-2}];
M = Surface density of gravitational charge [kg m^{-2}];
V_G = Gravitational potential [N m kg^{-1}] [m^2 s^{-2}];
Φ_G = Gravitational flux [N m^2 kg^{-1}];
q_G = Gravitational charge [kg];
I_G = Gravitational current [kg s^{-1}] [N s m^{-1}];
J_G = Surface density of gravitational current [kg s^{-1} m^{-2}];
ρ_G = Volume density of gravitational charge [kg m^{-3}];
γ_0 = Vacuum gravitational permeability [kg^2 N^{-1} m^{-2}] [kg s^2 m^{-3}];
k_G = Gravitostatic constant = 6.6739*10^{-11} [N m^2 kg^{-2}] [m^3 kg^{-1} s^{-2}];
I = Inertial field intensity [N s m^{-2}] [kg m^{-1} s^{-1}];
O = Surface density of inertial charge [s^{-1}];
V_I = Inertial potential [N s m^{-1}] [kg s^{-1}];
Φ_I = Inertial flux [N s] [kg m s^{-1}];
q_I = Inertial charge [m^2 s^{-1}];
I_I = Inertial current [m^2 s^{-2}];
J_I = Surface density of inertial current [s^{-2}];
ι_0 = Vacuum inertial permeability [m^2 N^{-1} s^{-2}] [m kg^{-1}];
F = Force [N] [kg m s^{-2}];
a = Acceleration [m s^{-2}];
v = Velocity [m s^{-1}];
ω = Angular velocity [rad s^{-1}];
r = Radial length (radius) [m];
l = Length [m];
S = Area [m^2];
t = Time [s].

2 Introduction

When a satellite is in a circular orbit, its velocity (linear and angular) and the distance to the center of the planet (orbit radius) does not change. This movement is called Uniform Circular Motion – UCM and is determined by a centripetal force acting on any object that is submitted to a central force problem. With satellites, this central force is gravitational and the equilibrium condition, when the orbit radius do not change, is determined by the equation:[1]

$$\vec{F}=q_G\vec{G}=q_G\vec{a}_G=q_G\frac{v^2}{r}\hat{r}=q_G\omega^2 r\hat{r} \qquad \vec{G}=\vec{a}_G=\frac{v^2}{r}\hat{r}=\omega^2 r\hat{r}$$

Here **G**[2] is the gravitational field, q_G is the gravitational charge (mass) of the satellite and r is the orbit radius.[2] We may see that the gravitational field **G** is the same gravitational acceleration $\mathbf{a_G}$ and both are equal to an acceleration directed radially to the center of gravitational charge (center of mass) – CM of the planet, called centripetal acceleration $v^2/r=\omega^2 r$. This mathematical condition is what maintains the satellite without falling.

We must pay attention on the fact that the gravitational acceleration is centripetal too, then it is not a force neutralizing other; there is no centrifugal acceleration. The gravitational force is what

2 You are invited to read the previous article Gravitational Charge to get acquainted with this new terminology.

maintains the satellite in a UCM movement; without it the satellite would have a linear movement. But we are really interested in the equilibrium elements of the centripetal acceleration: why there is no centrifugal force to equilibrate the centripetal force? We may study this phenomenon considering the following vectors involved in the movement:

- A radial gravitational field that is the cause of a centripetal acceleration and force;
- An object (the satellite) that is in a uniform circular motion and moving tangentially to the circular perimeter without falling.
- At any instant in the trajectory of the object, the gravitational force vector is perpendicular to the tangential velocity vector so, the force of the gravitational field is only modifying a linear motion into a circular one.
- At any instant in the trajectory, the object is submitted to a constant gravitational potential $V_G = G r = v^2$.

Analyzing the problem in this way lead us to a question: because we need one force to neutralize other, how can a velocity perpendicular to a force neutralize it? In other words, when an electric charge is at a constant electric potential V_E created by an electric field **E**, it gets moving submitted to a force $\vec{F} = q_E \vec{E} = q_E V_G / r$ so, why the satellite, in its equilibrium condition, do not move radially if it is at a constant gravitational potential V_G, created by the gravitational field **G**? Moving the satellite in a circular orbit is not sufficient to maintain its hight because there still is a force $\vec{F} = q_G \vec{G} = q_G V_G / r$ acting on it.

We are forced to admit that the constant gravitational potential V_G that the satellite is submitted to is, in some form, neutralized by the constant velocity of the satellite. If this neutralizing effect do not occur, the satellite would not maintain its circular orbit. We know two similar effects in electromagnetism:

1. Lorentz force: a moving electric charge or electric current inside a magnetic field suffers a force perpendicular to its trajectory and to the field.
2. Faraday's induction: an electric current produces a magnetic field perpendicular to it; a magnetic current[3] produces an electric field perpendicular to it.[3]

Considering the first effect, it is analogous to the Lorentz's force that occurs when electric charges travel with constant velocity inside a magnetic field. A radial electric field is established by the vectorial product $\vec{v} \times \vec{B} = \mu_0 \vec{v} \times \vec{H} = \vec{E}$, and it exerts a centripetal Lorentz's force that puts the electric charge in a circular orbit. The same effect occurs with an electric current in a wire inside a magnetic field, but the satellite is like an electric charge that is not inside a wire. So the force exerted on the electric charge is the cause of the charge moving in a uniform circular motion with a radius orbit r.

$$\vec{F} = q_E \vec{E} = q_E \vec{v} \times \vec{B} = q_E \mu_0 \vec{v} \times \vec{H} = q_E \frac{v^2}{r} \hat{r} = q_E \omega^2 \vec{r} \qquad \vec{E} = \vec{v} \times \vec{B} = \mu_0 \vec{v} \times \vec{H} = \frac{v^2}{r} \hat{r} = \omega^2 \vec{r}$$

We may see that these electromagnetic equations of force and field are similar to the gravitational force and field equations that determines the centripetal acceleration $v^2 / r = \omega^2 r$ on a satellite in a circular orbit of radius r:

$$\vec{F} = q_G \vec{G} = q_G \frac{v^2}{r} \hat{r} = q_G \omega^2 \vec{r} \qquad \vec{G} = \frac{v^2}{r} \hat{r} = \omega^2 \vec{r}$$

But the difference is that the gravitational field is already there, it is not produced by the vectorial product of satellite velocity and another surface charge distribution. The common thing is

3 Read the previous article Magnetic Charge to get informed about magnetic current.

the angular velocity of the circular orbit, and this tell us that the gravitational field only turns the uniform linear motion into a uniform circular motion.

Considering the second effect, it is like the gravitational charge, when moving with constant velocity, induces a gravitational field perpendicular to its trajectory that neutralizes or deviates the earth gravitational field. In other form, we may say that the satellite neutralizes the earth gravitational potential when it reaches a velocity determined by:

$$v^2 = G\,r = k_G \frac{Q_G}{r} = \frac{1}{4\pi\gamma_0}\frac{Q_G}{r} = V_G$$

We may confirm this comparing the units of measurement of the gravitational potential V_G, that is [N m kg^{-1}] [m^2 s^{-2}], and the velocity squared, that is v^2 [m^2 s^{-2}], they are the same. This situation is similar to the Faraday's induction law, where an electric potential is induced by a magnetic current, and both have the same unit of measurement [V] [Wb s^{-1}]:[3]

$$V_E = \frac{d\,q_M}{d\,t} = I_M$$

But the gravitational situation is not so clear, because there must be a current of another type of charge to produce a gravitational potential. Therefore, the velocity squared is equivalent to a current, that we call inertial current I_I, and it induces a gravitational potential V_G. We may see that it is not the gravitational charge (mass) with a velocity (equivalent to a gravitational current I_G) that induces the gravitational potential, but when the inertial current (velocity squared) is equal to the earth gravitational potential, the induced gravitational potential neutralizes it and the satellite maintains its orbit.

$$V_G = v^2 = \omega^2 r^2 = I_I = \frac{d\,q_I}{d\,t}$$

And we may think that an inertial field exists around the planet as a consequence of the volumetric distribution of gravitational charge of the earth in rotation. It is like a volumetric distribution of electric charge rotating produces a magnetic field; the existence of a longitudinal magnetic field around the earth is a proof of this effect.

So, we may substitute the mechanical (gravitoinertial) counterparts of the electromagnetic phenomenon and obtain new elements for mechanic equations. In this analogy, the electric charge and field have its analog counterparts gravitational charge and field; the magnetic charge and field have its counterparts inertial charge and field. The same difficulty in finding magnetic monopole exists in finding inertial monopole.

3 Inertial Current and Inertial Charge

We know that a current is the quantity of charges by unit of time and it was demonstrated that inertial current I_I is velocity squared, that has unit of measurement [m^2 s^{-2}]. Considering an object moving linearly with velocity v or rotating about an axis out of its body, we may equate its inertial current by its velocity squared or surface density of inertial current J_I, that has unit of measurement [s^{-2}]:

$$I_I = v^2 = \omega^2 r^2 = \int_S \vec{J}_I \cdot d\vec{S} = \frac{d\,q_I}{d\,t}$$

The surface density of inertial current $\mathbf{J_I}$ has the same direction of the velocity vector **v**. We may extend this concept of inertial current with the integration of acceleration along the trajectory line considering that:

$$\vec{a}=\frac{d\vec{v}}{dt} \qquad \vec{v}=\frac{d\vec{l}}{dt}$$

$$I_I=\int_i^f \vec{a}\cdot d\vec{l}=\int_i^f \frac{d\vec{v}}{dt}\cdot d\vec{l}=\int_i^f \frac{d\vec{l}}{dt}\cdot d\vec{v}=\int_i^f \vec{v}\cdot d\vec{v}=\left[\frac{v^2}{2}\right]_I^f=\frac{1}{2}(v_f^2-v_i^2)$$

This equation gives medium quadratic velocities between initial and final velocities, which corresponds to medium inertial currents. It is used in calculating kinetic energy received by the accelerated gravitational charge.

There is, too, another inertial current with rotation about the center of gravitational charge (center of mass) – CM, where the linear velocity is changed by angular velocity with $v=\omega r$, considering that r is the radius.

$$I_I=\omega^2\int_{r_1}^{r_2} r\,dr=\omega^2\left[\frac{r^2}{2}\right]_{r_1}^{r_2}=\frac{1}{2}\omega^2(r_2^2-r_1^2)$$

We see that the inertial charge q_I has unit of measurement [$m^2\ s^{-1}$]. This concept of inertial charge may be extended to the planetary motion under a central force: it establishes that the area swept out by the radius vector from the sun to a planet in equal times are equal, and this is known as a consequence of the conservation of angular momentum $L=q_G\omega r^2=q_G v r$. This time, we may attribute this establishment to the conservation of charge (gravitational and inertial) and define:

$$q_I=\omega r^2=v r \qquad L=q_G q_I$$

4 Inertial Field and Surface Density of Inertial Charge

Like the electric field is obtained knowing the force exerted by it on an electric charge:

$$\vec{F}=q_E\vec{E} \qquad \vec{E}=\frac{\vec{F}}{q_E}$$

So, the inertial field equation is:

$$\vec{F}=q_I\vec{I} \qquad \vec{I}=\frac{\vec{F}}{q_I}$$

Like its electric field counterpart has unit of measurement force/electric charge or electric potential/distance or magnetic current/distance, the unit of measurement of I is [$N\ s\ m^{-2}$] [$kg\ m^{-1}\ s^{-1}$], that is, force/inertial charge or inertial potential/distance or gravitational current/distance.

Now we may define the surface density of inertial charge **O** like the surface density of electric charge **D**, considering that in a surface there are a total inertial charge q_I:

$$\int\vec{O}\cdot d\vec{S}=q_I \qquad O=\frac{q_I}{S}$$

The surface density of charge **O** is defined as inertial charge [m^2 s^{-1}] over area [m^2], and this lead us to a unit of measurement [s^{-1}], that is a frequency. This frequency is naturally angular and is linked to angular velocity.

In the vacuum of space there are simple relations between inertial field **I** and surface density of inertial charge **O**: $\vec{O}=\iota_0\vec{I}$. Here we use ι_0 as the inertial permeability of vacuum, that has unit of measurement [m kg^{-1}] or [$(m^2\ s^{-1})^2\ N^{-1}\ m^{-2}$], like its electric counterpart ε_0 has [$C^2\ N^{-1}\ m^{-2}$].

5 Inertial Flux

The inertial flux Φ_I in space that pass through an open surface S with a surface distribution of inertial charge may be equated like its electric flux counterpart Φ_E:

$$\Phi_I=\int_S \vec{I}\cdot d\vec{S}=\frac{q_I}{\iota_0}$$

The inertial flux indicates the quantity of lines of inertial force field that pass through the area. This is, a limited area that has a surface density of gravitational charge has a total quantity of charge that may be equated by:

$$q_I=\int_S \vec{O}\cdot d\vec{S}=\iota_0\int_S \vec{I}\cdot d\vec{S}=\iota_0\Phi_I$$

Then we may identify two types of inertial current: conduction and displacement. The first being the inertial charge variation by unit of time for inertial conductors, and the last being the inertial flux variation by unit of time for inertial isolators.

$$I_I=\frac{d}{dt}\int_S \vec{O}\cdot d\vec{S}=\iota_0\frac{d}{dt}\int_S \vec{I}\cdot d\vec{S}=\iota_0\frac{d\Phi_I}{dt}$$

With this, we may establish a Faraday’s induction law for gravitational potential:

$$\oint_L \vec{G}\cdot d\vec{l}=I_I+\iota_0\frac{d\Phi_I}{dt} \qquad \nabla\times\vec{G}=\vec{J}_I+\iota_0\frac{\partial\vec{I}}{dt}=\vec{J}_I+\frac{\partial\vec{O}}{dt} \qquad V_G=-\oint_L \vec{G}\cdot d\vec{l} \qquad \vec{G}=-\nabla V_G$$

6 Inertial Potential

The inertial potential may be defined like its electric counterpart[1], along the line between two points inside an inertial field:

$$V_I=-\int_a^b \vec{I}\cdot d\vec{l}$$

We may extrapolate to deduce an equivalent to Ampere’s induction law for the inertial potential establishing that the integral of the inertial field around a closed line that encircle an area passed through by a gravitational current is equal to the gravitational current enclosed by the line. This is like a conduction current for gravitostatic fields on gravitational conductors (transport of fluids).

$$\oint_L \vec{O}\cdot d\vec{l}=\iota_0 I_G \qquad \oint_L \vec{I}\cdot d\vec{l}=\int_S \vec{J}_G\cdot d\vec{S}=I_G=\frac{dq_G}{dt}$$

And extend this equation with the gravitational flux variation by unit of time like a displacement current for gravitodynamic fields on gravitational isolators. The complete equations in integral and differential forms are:

$$\oint_L \vec{I}\cdot d\vec{l} = I_G + \gamma_0 \frac{d\Phi_G}{dt} \qquad \nabla\times\vec{I} = \vec{J}_G + \gamma_0 \frac{\partial\vec{G}}{dt} = \vec{J}_G + \frac{\partial\vec{M}}{dt} \qquad V_I = -\oint_L \vec{I}\cdot d\vec{l} \qquad \vec{I} = -\nabla V_I$$

7 Gravitational Neutralization

We have seen in the introduction that an inertial current, by some form of induction, produces a neutralizing gravitational potential that maintains the satellite in orbit without falling. We may think that it is a form of induction because the neutralized earth gravitational field is perpendicular to the inertial current (velocity squared). A more rigorous form to express this is like its electric induction counterpart, since the induced gravitational field must be opposite to the earth gravitational field:

$$\int_L \vec{G}\cdot d\vec{r} = v^2 = \omega^2 r^2 = I_I = \frac{dq_I}{dt} \qquad V_G = -\int_L \vec{G}\cdot d\vec{r}$$

There are two forms to interpret this equation: linear inertial current and angular inertial current. Both forms may neutralize the earth gravitational potential so, instead of moving a gravitational charge with a linear velocity, we may put it with an angular velocity rotating about its center of gravitational charge – CM.

With satellites occurs the first case; all the parts of the object are at the same speed. An analog case may be the horizontal moving of a projectile, with the gravitational force perpendicular to its initial trajectory. Its falling time is the same of its free fall but, if its inertial current (velocity squared) is equal to its earth gravitational potential, it will not fall, considering the atmospheric attrition does not reduce its velocity.

To get some idea about the magnitude of these velocities on the surface of the earth, we will use the gravitational potential on the equator of the earth:

$$V_G = k_G \frac{q_G}{r} = 6.6739*10^{-11} \frac{5.976*10^{24}}{6.378*10^{6}} = 6.253*10^7 m^2 s^{-2}$$

The velocity in which the projectile does not fall is:

$$v = \sqrt{V_G} = \sqrt{k_G \frac{q_G}{r}} = \sqrt{6.253*10^7} = 7.9*10^3 m\, s^{-1}$$

If it would be possible for an object of any weight to maintain this speed, it would not fall, like the satellite that do not have attrition with the atmosphere maintains its orbit.

The second case occurs when we put an axially symmetrical body (cylinder like a gyroscope or disc) rotating about its axis. All parts are at the same angular velocity and we must calculate the linear velocity by an equation that it was already presented, considering it has constant mass density:

$$I_I = \omega^2 \int_{r_1}^{r_2} r\, dr = \omega^2 \left[\frac{r^2}{2}\right]_{r_1}^{r_2} = \frac{1}{2}\omega^2 (r_2^2 - r_1^2)$$

With a cylinder or disc with an internal radius of the disc $r_1 \approx 0$ and $I_I = V_G$ (loose all its weight) and external radius r = 0.5 m, it will levitate when its rotation reach:

$$V_G = I_I = \frac{1}{2}\omega^2 r^2 \qquad \omega = \frac{\sqrt{2V_G}}{r} = \frac{\sqrt{2*6.253*10^7}}{0.5} = 2.24*10^4\, rad\, s^{-1}$$

In rotations by minute – RPM, this corresponds to:

$$v_{RPM} = \frac{60}{2\pi}\omega = \frac{60}{2\pi}2.24*10^4 = 2.14*10^5\, RPM$$

With 214,000 rotations by minute it is possible to neutralize the earth gravitational potential in the surface of the planet and make this disk levitate. This is the earth scape angular velocity for this disc. Augmenting the rotation the disc will lift up. But in real cases, there are stationary parts of the equipment that are not in rotation and this excess of gravitational charge must be compensated increasing the disc rotation.

So, the equation to use is for gravitational (potential) energy U_G and it must consider the two types of gravitational charge: total charge of the equipment Q_G and the charge of the rotating disc q_G. In the surface of the earth equator we may use the gravitational potential V_G already calculated; in other cases we must consider the new radius.

$$U_G = Q_G V_G = q_G \frac{1}{2}\omega^2 r^2 \qquad \omega = \frac{1}{r}\sqrt{\frac{2V_G Q_G}{q_G}}$$

As an application example, lets rotate a disc with external radius = 1.5 m, internal radius ≈ 0 m, disc gravitational charge = 5 kg and total gravitational charge = 10 kg. To neutralize 3% (300 g) of total gravitational charge we have:

$$\omega = \frac{1}{r}\sqrt{\frac{2V_G Q_G}{q_G}} = \frac{1}{1.5}\sqrt{\frac{2*6.253*10^7*0.03*10}{5}} = 1.83*10^3\, rad\, s^{-1}$$

$$v_{RPM} = \frac{60}{2\pi}\omega = \frac{60}{2\pi}1.83*10^3 = 1.74*10^4\, RPM$$

8 Conclusion

It is presented a new field, called inertial field, and the mathematical treatment for the satellite orbits in space with a new interpretation for the gyroscopic effect that permits us to overcome gravity simply spinning discs in high rotations.

This inertial field interacts with the gravitational field like the magnetic field interacts with the electric field. We have now equations for inertial quantities that are similar to its magnetic quantities and we may use the same mathematical tools that we use for electromagnetism in calculating mechanic (gravitoinertial) quantities.

Units of measurement of the new inertial quantities are: charge [$m^2\, s^{-1}$], current [$m^2\, s^{-2}$], flux [N s] [$kg\, m\, s^{-1}$], field [$N\, s\, m^{-2}$] [$kg\, m^{-1}\, s^{-1}$], potential [$N\, s\, m^{-1}$] [$kg\, s^{-1}$], surface density of charge [s^{-1}], surface density of inertial current [s^{-2}], vacuum inertial permeability [$m^2\, N^{-1}\, s^{-2}$] [$m\, kg^{-1}$]; all are obtained with similar formulations to their magnetic counterparts.

	Magnetic		Inertial	
Greatness	**Equation**	**Unit**	**Equation**	**Unit**
Field from a surface charge	$H(r)=\frac{1}{4\pi\mu_0}\int_S \frac{\vec{B}\cdot d\vec{S}}{r^2}$	[N Wb^{-1}] [A m^{-1}]	$I(r)=\frac{1}{4\pi\iota_0}\int_S \frac{\vec{O}\cdot d\vec{S}}{r^2}$	[N s m^{-2}] [kg m^{-1} s^{-1}]
Field from a scalar potential	$\vec{H}=-\nabla V_M$	[N Wb^{-1}] [A m^{-1}]	$\vec{I}=-\nabla V_I$	[N s m^{-2}] [kg m^{-1} s^{-1}]
Surface charge density	$\vec{B}=\mu_0\vec{H}$	[Wb m^{-2}]	$\vec{O}=\iota_0\vec{I}$	[s^{-1}]
Flux	$\Phi_M=\int_S \vec{H}\cdot d\vec{S}$	[N m^2 Wb^{-1}] [A m]	$\Phi_I=\int_S \vec{I}\cdot d\vec{S}$	[N s] [kg m s^{-1}]
Charge	$q_M=\int_S \vec{B}\cdot d\vec{S}=\mu_0\Phi_M$	[Wb]	$q_I=\int_S \vec{O}\cdot d\vec{S}=\iota_0\Phi_I$	[m^2 s^{-1}]
Current	$I_M=\frac{dq_M}{dt}=\mu_0\frac{d\Phi_M}{dt}$	[Wb s^{-1}] [V]	$I_I=\frac{dq_I}{dt}=\iota_0\frac{d\Phi_I}{dt}$	[m^2 s^{-2}]
Scalar potential	$V_M=-\int_L \vec{H}\cdot d\vec{l}$	[A] [C s^{-1}]	$V_I=-\int_L \vec{I}\cdot d\vec{l}$	[N s m^{-1}] [kg s^{-1}]

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