TITLE

“Is the Equivalence principle correct?”

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ABSTRACT

The Equivalence principle.

"Bodies which are moving under the sole influence of a gravitational field receive an acceleration, which does not in the least depend on the material or the physical state of the body. For instance, a piece of lead and a piece of wood fall in exactly the same manner in a gravitational field (in vacuo) when they start off from rest or with the same initial velocity."

There appears to be an error in the formation of the equivalence principle (and here the author gives the evidence of that error), which when corrected would lead to a new understanding of stellar formation and planetary orbits, including an explanation of why trinary star systems are not observed - as opposed to a binary pair with another star orbiting that pair (or vice versa).

Einstein used a Gedankenexperiment with a man in a chest, to prove that falling objects of differing masses all fall at the same rate for the man in the chest who is being accelerated at a steady 9.8 m/s^2, and the man on Earth who is experiencing 9.8 m/s^2 of gravity. It can be proved that the equivalence principle does not hold when the falling object used as an example is an extremely large mass. The logical conclusion therefore is that by reducing the extremely large mass down to more normal mass values, although the objects appear to fall at the same rate, they do not, but as the difference is minute, it can be, and is, customarily ignored. This does not matter on Earth, but it does matter a great deal for planetary formation and orbits, and for stellar and galactic formation.

All references are to “Relativity The Special And The general Theory” by Albert Einstein, first published by Methuen and Co 1920. The edition referenced was published by University Paperback in 1976.

In chapter XIX, Einstein makes the following statement.
"Bodies which are moving under the sole influence of a gravitational field receive an acceleration, which does not in the least depend on the material or the physical state of the body. For instance, a piece of lead and a piece of wood fall in exactly the same manner in a gravitational field (in vacuo) when they start off from rest or with the same initial velocity."
When watching a piece of lead and a piece of wood fall, they appear to fall in exactly the same manner. This paper will show that they do not, and the lead actually falls faster, but the difference is minute, and is customarily ignored.
The Equivalence Principle (chapter XX) states "It is not possible by experiment to distinguish between an accelerating frame and an inertial frame in a suitably chosen gravitational potential, provided that the observations take place in a small region of space and time".
Einstein states that all objects, when dropped, will fall to the floor with equal acceleration, whether the chest is in a gravitational field or is being accelerated by an outside force. This paper will show that statement to be in error. Appearances can be deceptive. We will assume that we are on the surface of the Earth. If you picture a mass the equivalent of the Earth, but compressed to a size similar to that of the wood or lead under discussion (it is immaterial what this mass is, but it might be convenient to picture a miniature black hole), and hold it suspended by some means, when that mass is dropped, the observed acceleration will not be 9.8m/s^2, but 19.6m/s^2 . As the Earth’s surface gravity is 9.8m/s^2, and that of the miniature black hole is also 9.8m/s^2 (at a distance of 6,371,000 m), we can immediately see that the gravitational attraction is a result of the attraction of both bodies’ gravitational fields. This applies whatever the mass of the bodies, and explains why the wood and the lead appear to behave the same - their mass is so tiny when compared to that of the Earth, that for all practical purposes when dealing with the Earth, they are identical in mass.

[experiment 1].
We will assume that the man in the chest is being accelerated at 1G by an outside force (the hypothetical being pulling on the rope, or a reaction motor etc). If he drops a piece of lead or a miniature black hole, they will both fall with an acceleration of exactly 9.8m/s^2 - not a hair under or over. The objects are quite simply left behind as the chest accelerates away. If these objects are at a height of 20 meters to start with, they will take 2 seconds from release to hitting the floor of the chest.

[experiment 2].
Let us now assume that he is in the gravitational field of the Earth with the floor of the chest standing on the surface of the Earth. The objects are at a height of 20 meters, so that at 9.8m/s^2 acceleration, they should take 2 seconds to hit the floor. However, the miniature black hole falls with an acceleration as seen from Earth of 19.6 m/s^2 , and will hit the floor after 1.4 seconds. The Earth and the black hole are of course in fact each accelerating at 9.8 m/s^2 towards their common centre of gravity. Contrast this with the piece of lead, which will hit the floor of the chest after 2 seconds. The answers of 2 and 1.4 seconds are rounded down for simplicity.

Now to apply some mathematics. The formula used is :-

A = acceleration = G (M + m) / (R + h)^2
Where :-
G = gravitational constant = 6.674e-11
R = radius of the Earth (6371000 m)
M = mass of the Earth (5.9723e24 Kg)
h = height of object to be dropped above the Earth’s surface

m =   mass of the object to be dropped
Units are meters, kilograms, and seconds

Notice that the above formula differs from the "classical" formula by including both the Earth mass and the mass of the object to be dropped, and the height of the object to be dropped above the surface. Conventionally these are ignored.

Here is the result of the MBH being dropped from 20 meters :-
A(mbh) = 6.674e-11 * (5.9723e24 + 5.9723e24) / (6371000 + 20)^2
= 19.6 m/s^2

Time of fall of MBH : Tmbh   = sqrt (2h/A(mbh))
T(mbh) = sqrt(2 * 20 / 19.6)
= 1.4 s

Here is the result of the mass of 1 Kg being dropped :-
A(1) = 6.674e-11 * (5.9723e24 +1) / (6371000 + 20)^2
= 9.819 782 789 471 481 602 210 770 149 616 5 m/s^2 (spaces for clarity, given in full to be used later)
= 9.8 m/s^2

Time of fall :- T(1) = sqrt (2h/A(1)) = sqrt (2 * 20 / 9.8197827894714816022107701496165)
T(1) = 2.018 269 024 724 326 286 319 506 874 294 1 s
= 2 s : An observable difference of 0.6 seconds

In the above calculations, the 20 meters height of the object had no bearing on the answer and the time of fall was truncated to one decimal place with the difference being readily apparent.
The vast difference in acceleration and time of fall is quite obvious. Now the difference in acceleration will be shown between two masses which are capable of being manipulated (dropped) on Earth. The first is the 1 Kg mass (A1) above, the second (A2) is a 1,000 Kg mass shown below.

A(2) = 6.674e-11 * (5.9723e24 +1000) / (6371000 + 20)^2
= 9.819 782 789 471 481 602 212 412 756 935 9 m/s^2

Now compare A(1) with A(2)
A(1) = 9.819 782 789 471 481 602 210 770 149 616 5 m/s^2

It can be seen that the acceleration of the 1,000 Kg mass is higher than the 1 Kg mass.
Time of fall :- T(2) = sqrt (2h/A(2)) = sqrt (2 * 20 / 9.8197827894714816022124127569359)

T(2) = 2.018 269 024 724 326 286 319 338 070 994 4 s
T(1) = 2.018 269 024 724 326 286 319 506 874 294 1 s

Subtracting T(2) from T(1) , time difference is :- 0.0000000000000000000001688033 s
Or 1.688033e-22 s

For comparison, 1 picosecond is 1e-12 , or 0.000000000001 second. The difference in fall time between a 1Kg mass and a 1,000Kg mass is minute, but it is there nonetheless. This is just not measurable here on Earth for these masses.

To summarise then, if the experiments are done under a uniform acceleration of 1G, both the black hole and the lead will hit the floor after 2 s. If the experiments are done in a gravitational field of 1G, the black hole will hit the floor after 1.4s, but the lead will hit the floor after 2s. He can immediately decide from this experiment whether he is in a gravitational field or is being accelerated by an outside force. If a black

hole with a mass the same as that of the Earth falls faster than a piece of lead, then so does a mass of half the Earth, as does a mass of one hundredth, or a thousandth etc. In principle, if the man's instruments are sensitive enough, he can detect whether he is in a gravitational field or being accelerated, whatever the mass of the objects which he drops.
When watching a piece of lead and a piece of wood fall, they appear to fall in exactly the same manner. They do not. The lead actually falls faster, but the difference in acceleration is so minute that it cannot easily be measured, and can be ignored for all practical purposes. Is it possible that Einstein did not know this?

When Johannes Kepler wrote his equations for planetary orbital motion in the early part of the 17th century, he assumed a point mass for gravity, and ignored the mass of the secondary, which resulted in an approximation. This approximation is good enough for everyday objects on Earth, but not for planets in the solar system.
Following the above logic, a heavy (man made) satellite would orbit faster than a lighter one in the same orbit, but the effect would be far too small to be noticed. This got me to wondering just how large (massive) a satellite would have to be for this effect to be noticed, which in turn led to a rather unexpected conclusion.
Here is the scenario, and although a satellite has not been put into orbit at the stated distance, there is no reason why it cannot be, so in that respect, it is real. A satellite will be put into a specific orbit, and its orbital period and velocity calculated. The orbital period and velocity of a heavier satellite in the same orbit will also be calculated. The orbits are assumed to be circular.

R = distance between centres of mass. ie orbit radius = 384,404,000 m
G = the gravitational constant = 6.674e-11
C = circumference of orbit
Me = the mass of the earth = 5.9723e24 Kg
Mm = the mass of the moon = 7.34767e22 Kg
Ms = the mass of the satellite (for a man made satellite not normally taken into account, here it is assumed to be 1,000 Kg)

The formula to use to determine the satellite's period (Ps) is :-
Ps = 2 * pi * sqrt(R^3 / G * (Me + Ms))
Ps = 6.2831853 * sqrt(384404000^3 / 6.674e-11 * (5.9723e24 + 1000))
= 2,371,907.8 seconds
= 27.45 days.

For a satellite of 1,000,000,000 Kg the period (in seconds) is the same to 9 decimal places. From that it can be seen why the mass of a man made satellite is not normally taken into account when calculating orbital velocity, as increasing the mass by a million will result in an orbital period difference of 2e-10 seconds in 27.5 days.

The circumference of the satellite's orbit is :-
C = 2 pi R = 6.2831853 * 384404000 = 2,415,281,562.0612 m

Therefore the velocity of the satellite is :-
Vs = C / Ps = 2415281562.06 / 2371907.81
= 1,018.28 m/s

The orbital radius used above is that of the moon's orbit so now its period is calculated :-
Pm = period of orbit of the moon.
Mm = mass of the moon = 7.34767e22 Kg

Pm = 2 * pi * sqrt(R^3 / G * (Me + Mm))
= 6.2831853 * sqrt(384,404,000^3 / 6.674e-11 * (5.9723e24 + 7.34767e22))
= 2,357,450.3 seconds
= 27.28 days

The circumference of the moon's orbit is the same as the satellite's (but not concentric with it) :-

C = 2,415,281,562.06 m

The velocity of the moon is :-
Vm = C / Pm = 2415281562.06 / 2357450.39
= 1024.53 m/s

The velocity difference between satellite and the moon is :-
Vd = Vm - Vs = 1024.53 - 1,018.28
= 6.25 m/s

The moon is faster than the man made satellite by 6.24 m/s, and if the satellite were launched to be on the opposite side of the earth from the moon when it went into orbit, the moon would gradually catch up with it until they collided. This would take about 6 years.

I used Fortran to create a flexible program to calculate orbital velocities from various orbits and masses (Fortran and calculator results are slightly different, but within acceptable limits). The program is available here for you to check and experiment with, but it treats the masses as point sources, so will not be accurate with a low radius orbit around a large mass :-

http://myweb.tiscali.co.uk/carmam/sat11.exe

The source code is here :-

http://myweb.tiscali.co.uk/carmam/sat11.f95

Using the programme, put the Earth into the same orbit as Jupiter, you will see that they collide in about 12,000 years
Here is the unexpected conclusion which has emerged: No trinary star systems will be found in the universe. I define a trinary system as
1) A system in which the central more massive body has two other bodies in orbit around it in the same plane and which are nearly equal in orbit radius, or
2) Three bodies orbiting around their common centre of mass.

If a star system such as 1) formed in the first place, the two stars which were similar in mass but less massive than the primary would collide to form a binary system: or if 2) if the triangle formed by the three stars was equilateral (possible but not probable), due to the differing velocities this triangle would shift to be non equilateral (this would seem to be a more probable starting point, and is similar to system 1), and then the two closest stars would collide. As they did so, a binary system would form. A trinary system can only exist for a very short time relative to the age of the universe, and could only be found in very young star systems.
The calculations above show that a trinary star system is not stable. As can be seen, because satellites of differing masses in the same orbit move at different speeds, there will not be any trinary systems in the universe, except perhaps in very young star systems, which will not last long before they collapse into a binary.