# GRAVITY

Bertrand Wong, Eurotech, S'pore Branch
Email: bwong8@singnet.com.sg

**Abstract**
**Newton accidentally discovered gravity after observing an apple falling from a tree. What exactly is gravity? This paper takes a look at gravity, which evidently remains a subject of mystery.**

## Interpretations Of Gravity

Einstein had attempted to unify the four forces of nature, i.e., gravity, weak nuclear force, strong nuclear force and electromagnetism, but had failed. As in the past, he was unable to derive the electromagnetic field equations, even for the weak-field approximation. He was to live to the end of his life without any success with the unified field theory.

To arrive at this grand unified theory a better understanding of gravity would be necessary, e.g., its roles in the micro-world of the quantum particles and in our macro-world. It is thought that quantum particles are free from the effect of gravity, which seems only to have a negligible effect on them, unlike in the macro-world. Nobel Laureate Richard Feynman had posited that gravity could be totally unlike what it had been thought to be, thus possibly making unification with the other three forces impossible. Feynman had suggested that anti-particles are like ordinary particles moving backwards in time, which implies that anti-particles should have anti-gravity. In fact, there is the belief that there is an anti-gravitational force for every gravitational force, just as there is an anti-particle for every particle.

In the Theory of Special Relativity published in 1905, Einstein introduced the gravitational force which was considered responsible for the orbits of planets, as was described by Newtonian gravity. In Newton's law, gravity was an instantaneous force which propagated through space infinitely fast. This was evidently at odds with Einstein's Theory of Special Relativity which postulates that nothing can exceed the velocity of light.

In 1915 Einstein published the General Theory of Relativity which introduced a new theory of gravity that was compatible with the special theory. In this theory the space-time continuum was introduced wherein empty space was likened to a flat rubber sheet which was flexible - a massive object creates an indentation in this empty space, or, “rubber sheet” - this indentation is hence interpreted as a gravitational effect, a curved space-time, a geometry. In fact, in general relativity massive objects affect the way space-time curves. The link between an object’s mass and the space-time curvature can be worked out, which is encapsulated in Einstein’s all-important “field equations”. In this way Einstein was finally able to bring gravity in line with relativity.

Gravitation has always been thought of as a pulling or attracting force, just like the force of attraction between two magnets. Gravitation and magnetism may be different manifestations of the same thing. And, gravity may be a pushing force instead, a force that presses down on all objects in the direction of the centre of the earth. In fact, a push is equivalent to a pull, the former originates at the back of an object while the latter originates at the front. So far, gravitational forces are seen as forces of attraction only, while magnetic and electric forces are forces of attraction and repulsion. There may be a gravitational force of repulsion.

Gravity, which is crucial in the formulation of a unified field theory, can be described by the following formula:-

$$F = G \frac{M_1 \quad M_2}{R^2}$$

where F is the gravitational force of attraction, G is the gravitational constant, $M_1$ and $M_2$ are the masses of two objects and $R^2$ is the distance between masses.

Before Newton discovered gravity, nobody had known it existed or had thought that there was such an attractive force. However, Einstein in his General Theory of Relativity interpreted it as a curvature of the space-time continuum, a geometrical form, as is described above. Can gravity be the fifth dimension, in addition to the four dimensions of General Relativity comprising of the three physical dimensions and the time dimension, as Theodor Kaluza had suggested, which impressed Einstein greatly?

According to Einstein’s theory of gravity, the hypothetical quantum of gravity, the graviton, which is a spin-2 boson, interacts extremely weakly with other matter, far more weakly than neutrinos; it is so weak that no instruments so far have been able to detect it. In the supergravity extension of this theory of gravity, the graviton finds a superpartner, the gravitino, which is a spin-3/2 fermion. Under local supersymmetric transformations these two particles transform one into the other. When quantum calculations were carried out using supergravity theory, it was discovered that the infinities which plagued the earlier gravity theory with only the graviton were now being cancelled by equal and opposite infinities produced by the gravitino. This is evidently the result of the deeper consequence of the presence of supersymmetry. Though it is not certain whether the supergravity theory is completely renormalisable, this "softening of the infinities" appears to be a step toward a viable theory of quantum gravity. As simple supergravity theory includes only the graviton and the gravitino, this hardly corresponds to the real world with its many particles. Most of those who have worked on supergravity feel that some crucial idea is still missing. Without this crucial idea the theories simply do not describe the real world.

How do we make supergravity theory realistic? If we can solve this problem, we can have supergravity theory as a completely unified field theory. It has been shown that the principle of local supersymmetry is so restrictive that only eight possible supergravity theories exist, which are each labeled by an integer N = 1, 2 . . . 8. Supergravity theory shares the same features with its progenitor, the Theory of General Relativity, namely, conceptual power and mathematical complexity. Perhaps, by postulating the existence of a single master supersymmetry we can have a unified field theory that accounts for the whole universe.

The following is Einstein's equation for General Relativity:-

$$G_{im} = -\mathbf{K}(T_{im} - 1/2g_{im}T)$$

This beautiful equation expresses the curvature of space-time. The left-hand side refers to a set of terms which characterise the geometry of space, while the right-hand side refers to a set of terms which describe the distribution of energy and momentum, i.e., the left is the geometry side, while the right is the matter side. Reading from left to right is space-time telling mass how to move, while reading from right to left is mass telling space-time how to curve. In General Relativity, there is neither absolute time nor space and gravitation is not a force, or, pull between one object and another but a property of space and time. All this represents a great conceptual leap by the theory's creator, Einstein. As for the coordinate system of Einstein's General Theory of Relativity it has no basis in reality and is only a mental construct used to describe the space-time continuum of the General Theory of Relativity.

One may wonder when a unified field equation will be discovered. However, without a good understanding of gravity, this unified field equation will not come by easily. Once the experimental confirmation of the existence of the graviton, the hypothetical quantum of gravity, is achieved, we should be surer of obtaining a unified field equation that accounts for the whole universe, which may be supported by the existence of a single master supersymmetry. Superstring Theory now appears to pave the way towards achieving this difficult goal.

The search for gravitational waves is still ongoing. The existence of gravitational waves so far is inconclusive - there is only indirect evidence of their existence. In the gravitational effect known as frame dragging, objects occupying the space near to a rotating object get swept around with it; rotating objects drag space around with them rather like a spoon in treacle (syrup). In 2004, scientists analysing data from two Earth-orbiting satellites apparently found evidence of frame dragging - they claimed to have detected the minute frame dragging effect of our planet. There is the possibility of extracting useful energy from the rotation of our planet. There is speculation that this could serve as a power source for an advanced civilisation.

**Is Gravity Really What It Is Thought To Be?**

Is all the space occupied by us and around us really one immensely large, flexible sheet of curved space-time as is posited by the General Theory of Relativity? Or, is there an infinitude of such "flexible sheets"? That is, is gravity just one flexible sheet of curved space-time or more, perhaps infinitely more? Earth is a sphere but all of us are evidently "stuck to this sphere" and do not fall off it. What is the force, if it exists, which causes this? Will this force be an attractive or pulling force, or, a pushing force? Can gravity be a kind of fluid, whether air, gas or liquid? (We can descend, glide or fly up through the air like how a bird or an aeroplane does. We can dive into and descend in, surface in, float in, and swim in, a pool of liquid. All these may be interpreted as manifestations of "gravitational effect".) Can gravity be electrical, electronic, quantum or nuclear? Or, is gravity none of these but something else, as Richard Feynman had speculated?

It could be any intelligent person's guess.

**REFERENCES**


[1] Quantum Theory Of Matter, John Wiley & Sons, A. Modinos, 1996
[2] The Principles Of Quantum Mechanics, Oxford University Press, P. A. M. Dirac, 1958
[3] Concepts Of Modern Physics, Fifth Edition, McGraw-Hill, A. Beiser, 1995
[4] A Brief History Of Time, Bantam Book, Stephen Hawking, 1990
[5] Black Holes And Baby Universes And Other Essays, Bantam Book, Stephen Hawking, 1994
[6] Quantum Mechanics, Second Edition, John Wiley & Sons, E. Merzbacher, 1970
[7] Dreams Of A Final Theory (The Search For The Fundamental Laws Of Nature), Vintage, Steven Weinberg, 1993
[8] Superforce (The Search For A Grand Unified Theory Of Nature), Counterpoint, Paul Davies, 1984
[9] The Elegant Universe, Vintage Books, Brian Green, 2000
[10] Predictions From Quantum Cosmology, Physical Review Letters, Vol. 74, A. Vilenkin, 1995
[11] Life In The Infinite Universe, Quarterly Journal of the Royal Astronomical Society, Vol. 20, G. F. R. Ellis & G. B. Brundrit, 1979
[12] The Meaning Of Relativity, Princeton, Albert Einstein, 2005
[13] The Nature Of The Physical World, Comet Books, Arthur Eddington, 1928
[14] Wholeness And The Implicate Order, Routledge, David Bohm, 1980
[15] The Fabric Of Reality, Penguin Books, David Deutsch, 1997
[16] The Key To The Universe, Penguin Books, Nigel Calder, 1977
[17] The Evolution Of The Physicist's Picture Of Nature, Scientific American, P. A. M. Dirac, May 1963
[18] SlipString Drive: String Theory, Gravity, And Faster Than Light" Travel, iUniverse, Andrew L. Bender, 2006/2007
[19] The Special Theory Of Relativity, Routledge, David Bohm, 1996
[20] On The Electrodynamics Of Moving Bodies, Annalen der Physik, 17:891, Albert Einstein, June 30, 1905
[21] The Meaning Of Relativity, Princeton, Albert Einstein, 2005
[22] Modern Physics (4th. ed.), W. H. Freeman Company, Paul Tipler, Ralph Llewellyn, 2002
[23] An Aspect Of The Special Theory Of Relativity, The General Science Journal, Bertrand Wong, March 8, 2010
[24] The Special Theory Of Relativity: A Special View, The General Science Journal, Bertrand Wong, March 8, 2010
[25] The Special Theory Of Relativity: Further Views, The General Science Journal, Bertrand Wong, March 18, 2010