Gravity

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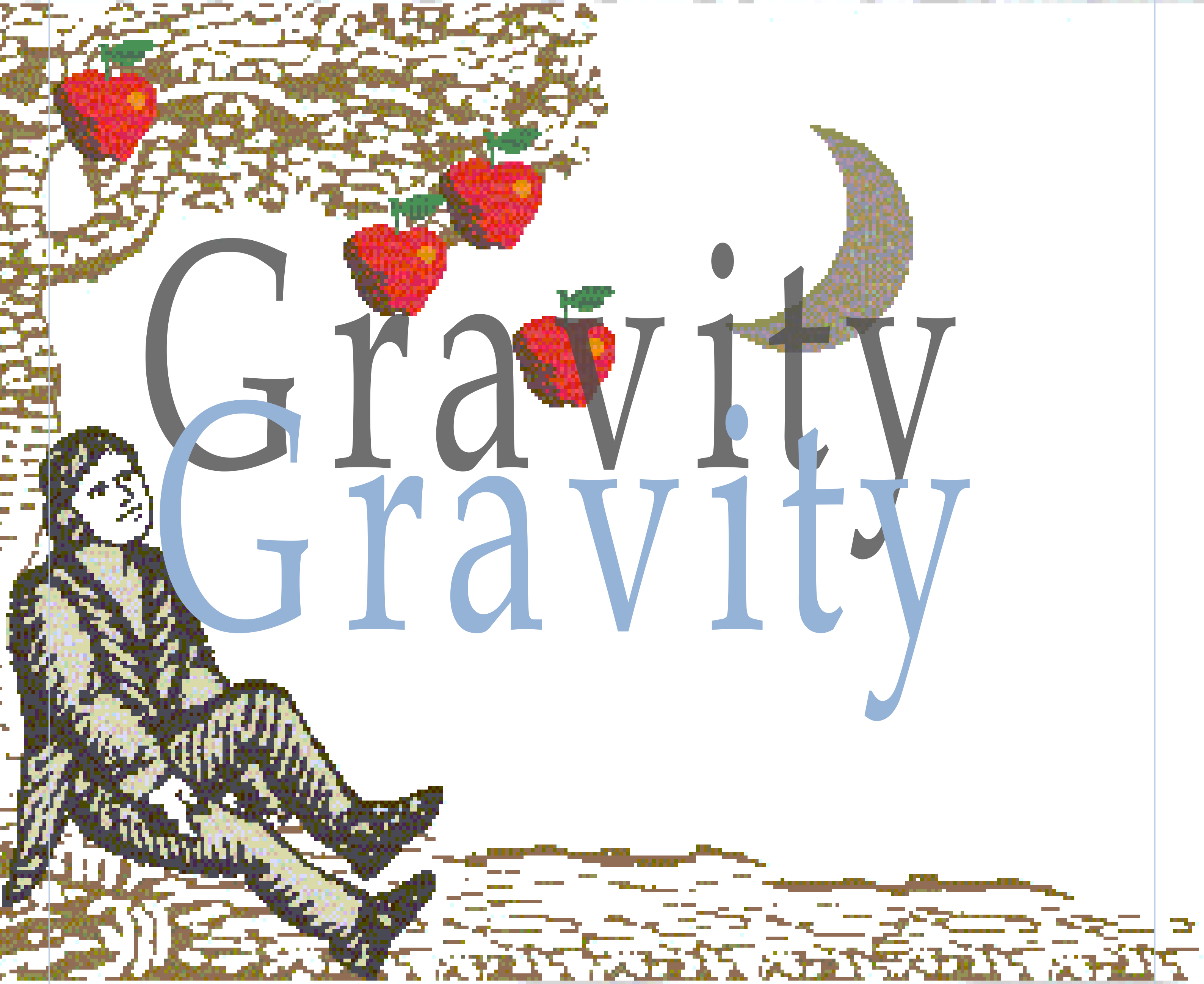

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Content

Prologue

More than what our eyes can see

The Universe has long sparked the fertile imagination of human kind, often, the dwelling place of deities. Romans, for example named Venus after the goddess of love, beauty and fertility and Mars after the god of war. Those earlier sky watchers associated celestial events with human events in what has been called as astrology. Furthermore, celestial events had altered the course of human history. When a solar eclipse occurred on May 28, 585 B.C. the Medes and the Lydians stopped a six year war seeing the eclipse as an omen.

Ancient astronomers saw an immaculate and unchanging universe, perfect in its composition and shape. It wasn't not until Galileo Galilei pointed out the first telescope to the naked sky that something outstanding would be revealed, mountains on the face of the moon, Saturn with giant ears and Jupiter with multiple moons.

The world was not quite getting accustomed to this new view of the universe when in 1672 Newton presented his discoveries about light to the Royal Society. Isaac Newton discovered through a prism that light is actually composed of many colours. By the early nineteen century William Werschel found out that some colors were hotter than other, but when moving the thermometer just outside of the red color; temperature would increase, although there was not light to reflect. That was one of the first discoveries that the light we can see is not all there is.

Until the 20th Century, astronomers thought that our Milky Way must have been all there was with respect to the universe. It wasn't until a giant telescope was built on Mount Wilson that Edward Hubble revealed that the fuzzy patches of sky called nebulae, were actually island universe just like our own.

Once again, scientist would discover that is not what it shines in the light that is important but what it hides in the darkness. Just when our eyes could see farther than ever before, other astronomer starting noticing a strange pattern. Stars on the edge of galaxies would move at the same speed that the star within the galaxy. This event would contradict the law of gravity, stars like planet in our solar system moves slower as they get further from the common center of gravity. Fritz Zwicky gave evidence of some "missing mass". An invisible matter was called on to account for this gap, named Dark Matter.

In the mid-time other strange phenomena were coming up to "light", such as black holes and dark energy. No matter how hard or how much we peep into the unknown, there always seems to be more undiscovered phenomena underneath of it all. If anything science has taught us is that there is always something more out there that what our eyes can see.

Gravity

There is a force in nature that remained hidden to mankind for thousands of years under a cloud of superstitions and philosophy. Natural Phenomenon, from the Greek “phainomenon” to show, shine, appear, thought to be the work of gods such as Osiris, the Egyptian god of death, rebirth and the afterlife. The evolution of mankind and the understanding of the heaven can be summaries in the words of the famous British Astronomer Sir Norman Lockyer (1836-1920) words. First the civilization goes into a state of worship in which the astronomical phenomena are view as the actions and mood of gods. Second, astronomy is used for terrestrial purposes such as cultivation and navigation. And finally, the heavens are study with the sole purpose of gaining knowledge.

Hundred years after the renascence in 1564 the “father of modern observational astronomy” was born. Galileo Galilei was the first that after the invention of the “spyglass” by Hans Lippershey would create a 3x magnification telescope that he would point toward the sky. After seeing the heavens with more detains that any other human in history, he published the treatise Sidereus Nuncius; The Starry Messanger.

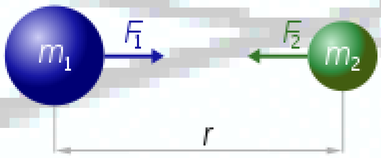
Almost hundred years after the birth of Galileo Galilei, one apple felt to the head of English Astronomer Sir Isaac Newton, or so the story goes. The most famous cliché of the history of Astronomy says that Newton drew inspiration by this event and wondered if it is the same force that make the apple fall that holds the moon and planets in orbit. As a consequence he wrote the Universal Law of Gravitation. Although Newton unveiled this hidden force to mankind and even made calculation on how to leave planet earth, the true is that he didn’t know what gravity was.

It would take almost 250 years and the mind of a genius to uncover what this force really is. Albert Einstein General Relativity of 1907 says that gravity is nothing else than the bending of the space-time mesh. Gravity, one of the fundamental forces of the universe is perhaps the more elusive and strange of them all. I invite you to take a look at its wonders and mysteries.

Gravity According To Sir Isaac Newton

"I deduced that the forces which keep the planets in their orbs must [be] reciprocally as the squares of their distances from the centers about which they revolve: and thereby compared the force requisite to keep the Moon in her Orb with the force of gravity at the surface of the Earth; and found them answer pretty nearly." Principia, 1687

This is a visual representation of Newton's equation:



F= force in Newton's
G=gravitational constant
m1= the first mass
m2 = the second mass
r= distance between the centers of the masses

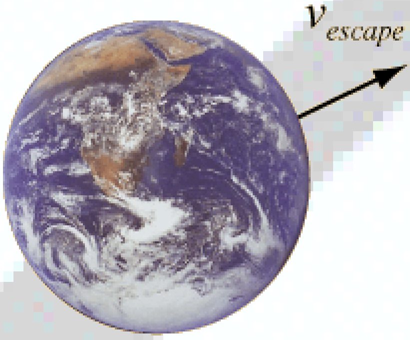
$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

The Newton is the unit used to measure gravity. Newton is the force require to accelerate a mass of a Kilogram at a rate of one meter per second squared. For instance if you hold a 100 grams apple, you are applying a force of one Newton, not to mention that you're holding a pretty small one since the average weight of an apple is 150 grams, more realistically it would take you 1,5 Newton's of apply force to prevent this apple from falling to the ground.

The gravitational constant is the force of one body exerts on another when multiplying the masses of the two bodies and dividing them by the square of the distance between them. In other words, if we have two 1 kg melons separated by 1 meter from its centers, the gravitational force would be 0.00000000006673 N. As we see, the attraction force is pretty weak! In case you're wondering, the average weigh of a melon is 2 to 5 kg!

Because now we know the force of gravity, we can know how we can leave planet earth by finding the escape velocity.

The formula is as follow:

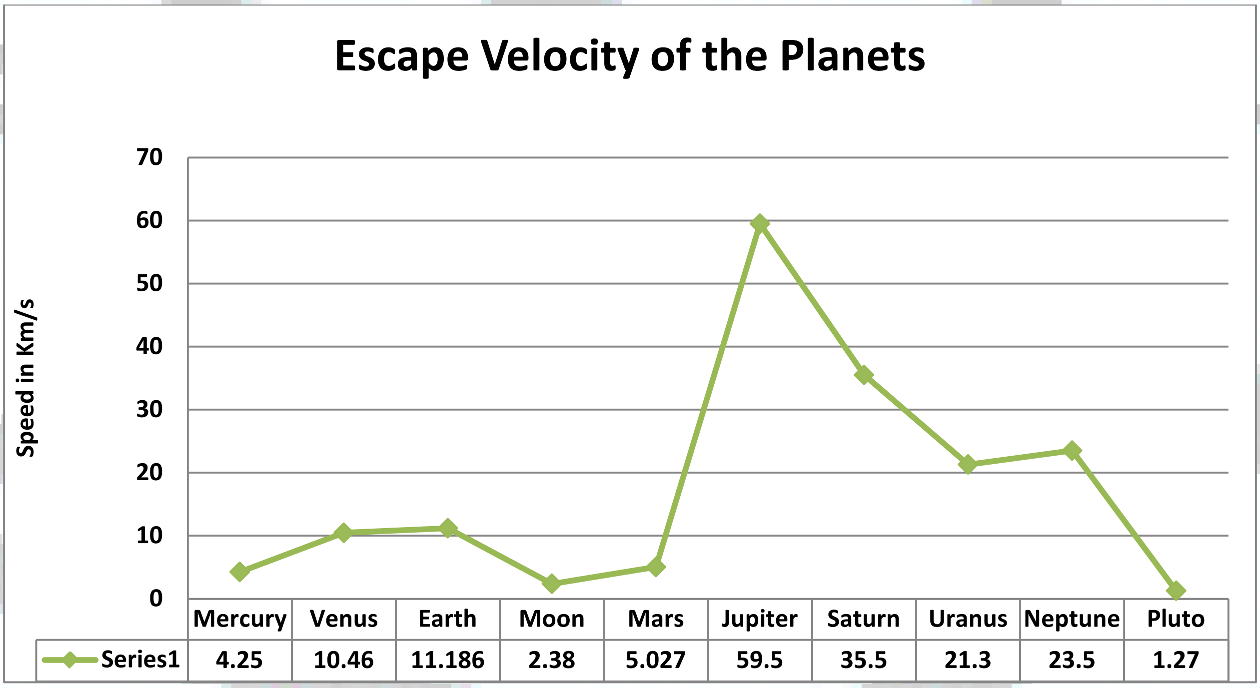


$$v_{escape} = 11.2\ km/s$$

$$\frac{1}{2}mv^2 = \frac{GMm}{r}$$

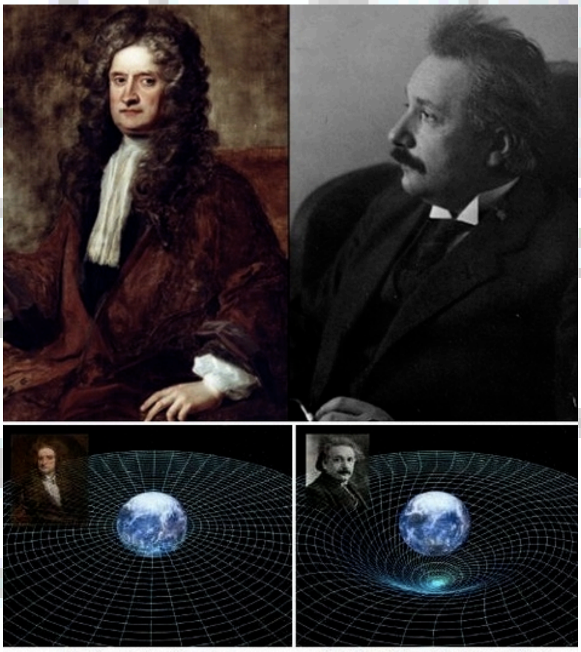
$$v_{escape} = \sqrt{\frac{2GM}{r}}$$

Again, m is the mass of the object, M is the mass of the earth, G is the gravitational constant, R is the radios of earth and v is the escape velocity. Once plotted the numbers it will tell you that the escape velocity of Earth is 11.186 km/s; of course this is without considering other modifiers such as air friction. Out of the rocky planets, the earth is the one with the highest escape velocity. Of the gas giants, the heavy weight to beat is Jupiter with an escape velocity of 59.5 Km/s. He is by the way our big brothers that protect us from most of the “interstellar debris” compose of comets and asteroids that may otherwise hit earth. Still, Jupiter escape velocity pales in comparison of the 1,000 Km/s that we would need if we want to escape the solar system all together!



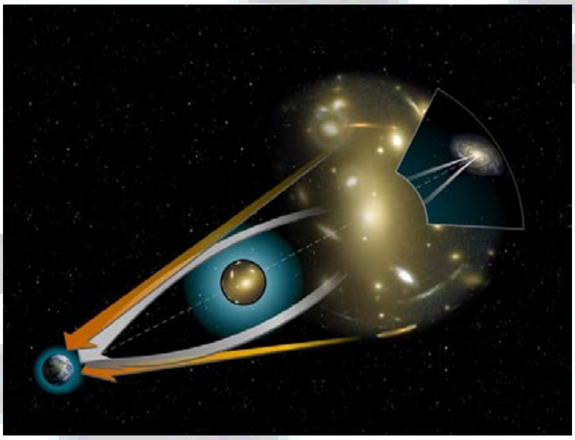
Gravity according to Albert Einstein

When Isaac Newton's Law of Universal Gravity refers on gravity as a force, Albert Einstein and his General Relativity Theory refers on gravity as the bending of space-time. Albert Einstein's General Relativity differs from Newton's Law of Universal Gravity concerning the passage of time, the geometry of space, the motion of bodies in free fall and the propagation of light. Some of the consequences of this law are the followings:

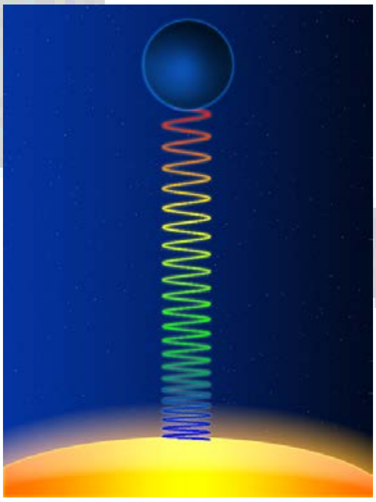


Newton's fixed space Einstein's flexible space-time

Gravitational Time Dilation: time is not universal but it runs at different rates, for instance the closer that we are to massive bodies, the slower that our clocks tics. Furthermore, the dilation of time is proportional to the acceleration that a body produce due to its gravitational field. This on earth is 9.8 m/ , therefore, we need the same the same acceleration on space for our watch to run on the same speed on earth.



Gravitational Lens: as light travels through a light of galaxies, it bends the space time and therefore the light passing through it producing a similar effect to the light passing to a set of glasses in as it is the case of the optical telescope.



Gravitational Redshift: As a light travels upwards from a gravitational field it loses some of its energy resulting in a longer wavelength.

Gravitational Time Delay: When a radar signal passes close to a massive object, it takes a little longer to get to the target and return. This is as a result of the gravitational time dilation named before.

Perhaps the most exciting and perplexing phenomena of the Einstein's Theory of General Relativity is the prediction of black holes.

Gravity and Black Holes

They might be considered as the monsters of our universe. They would devour anything that can close to its path as are virtually hidden from view .Its gravitational pulling is so strong that not even light can escape. Their birth come after the death of a giant star with the mother of all explosions called a supernova. As they devour whole stars and pull its space-time surrounding them, they make their presence evident to astronomers. And as it happen to be, they are everywhere and come in difference sizes.

Physical Properties: Unlike stars which share properties but has many different characteristics one from another, black holes has only three different physical properties: mass, charge and angular momentum. Any black holes with the same values are indistinguishable from another. This is often referring as the black holes information paradox.

Event Horizon: This is the point of no return. Passing this point information is lost to an outside observer forever. Here is where the bending of the space time is so strong that there is not path pointing toward anywhere else but the black holes itself.

Singularity: This is the region where the space-time curvature becomes infinite. When an object passes the event horizon its masses is crash into infinite density and its mass is added to the total mass of the black hole.

Supermassive black holes: these black holes are the biggest of them all. Its mass can reach up to a billion solar mass! It is thought that every galaxy may contain one of these giants. Counteintutitive as it may seem, the density of some of the is about the density of water! As consequence the tidal forces in the evernt horizon vecinity are pretty weak as well.

Intermediate-mass black holes: These are the less abudant of the all. Its masses are up to about a thousand solar.

Stellar black holes: These are the better known black holes that come directly from the collacting of a giant star, it masses is from about 3 solar masses and up.

Micro black holes: They also known as quantum mechanical back holes because of the effect of quantum mechanics on them.

Black hole classifications

Class	Mass	Size
Supermassive black hole	~10^5–10^9 M_{Sun}	~0.001–10 AU
Intermediate-mass black hole	~10^3 M_{Sun}	~10^3 km = R_{Earth}
Stellar black hole	~10 M_{Sun}	~30 km
Micro black hole	up to ~M_{Moon}	up to ~0.1 mm

Conclusion

As we can see, the history of the universe is a work in progress that its seem to reach not end. As we discover and understand phenomena, there is another underneath that remains to be understood. But it's the fertile imagination of human kind that makes it possible. As once Albert Einstein said "imagination is more important than knowledge"; perhaps because it opens to door to peep into the unknown. Human relentless effort to reach up to the stars it will never end; perhaps because as we look upward, we are looking inward to our own existence.

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