What Causes The Mass To Be Deficit Inside A Nucleus?

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Abstract: *There is ample amount of ambiguity regarding the concept of mass in present principles of physics. The mass of a gas nebula will be measured as the combined mass of all the atoms within that nebula. The only option for the measurement of mass of the same nebula when it collapses to a neutron star is by combining the mass of all the neutron particles. These two values of mass for the same object will never be the same. This is, in fact, against the definition of mass which states that the mass of an object is a fixed amount irrespective of the size of the object. It appears that our understanding of mass and the way we measure it is flawed.*

All the observations demonstrate that there will be deficit or gain in the mass of an object when there is a change in the volume of that object. An object measures more mass when the volume of the object was decreased. A neutron star is a compact form of the gas nebula from which it was collapsed, therefore the neutron star measures more mass or gravity than the gas nebula. A nucleus measures more gravity when all the particles were packed together in a small volume. The cause for the deficit of mass inside a nucleus is the increase in volume in which the particles were occupied.

Keywords: Deficit of mass, gravity, strong nuclear force, fission, binding energy, inverse square law, Avogadro constant, galactic orbital velocity, Pioneer anomaly, unification of fundamental forces.

The mass of a nucleus is always less than the combined mass of all the particles within the nucleus. The difference in these two values is called as the mass deficit in the nucleus. A simple answer for the cause of deficit is the binding energy inside the nucleus. Apart from this well known explanation, is there any other physical aspect of the nucleus we can attribute as the cause for the deficit?

The mass of two objects is the cause for the gravity between them. Therefore, the notion of mass deficit can also be described as the deficit in gravity between the object and earth. Because of the association between the mass and gravity, let's ignore the relevance of binding energy for a while and explore the deficit of mass in respect to the gravity.

According to the standard theory, the mass of an object is the object's resistance to change in motion. It is a fixed amount for a given object irrespective of the volume of the object. It means, even if the volume of the object decreases, the amount of mass it measures remains the same. This relation should hold true as long as the amount of matter inside the object remains the same. Does an object measure the same amount of mass even if the object collapses to a neutron star?

Mass of a Neutron Star with *n* Number of Neutrons

Let us assume that the number of neutrons inside a neutron star is n. What would be the mass of this neutron star? The only option to measure the mass of a neutron star is by multiplying the mass of a single neutron with the total number of neutrons in the star. In this case, the mass of the neutron star is proportional to the amount of matter, the number of neutrons, inside the star. Is this mass going to be consistent with the mass of the material from which the star was formed?

Let's consider the following two scenarios. A neon cloud with *X* moles of atoms collapsed to form a neutron star and another cloud of calcium dust with *X/2* moles of atoms collapsed to form another neutron star. Let's also assume that none of the material from these clouds got ejected when the clouds collapsed to form the neutron stars.

A neon atom contains ten of each basic particles; protons, neutrons and electrons. An atom of calcium contains double the amount of particles, 20 of each individual particle. A mole of neon measures 20.1791 grams of mass and a half mole of calcium measures (40.078/2) = 20.039 grams. Each of these two entities has same number of electrons, protons and neutrons but differ in the amount of mass they measure. The neon cloud will measure *X**20.1791 grams and the calcium cloud will measure *X* * 20.039 grams.

When a cloud collapses to form a neutron star, all the protons and electrons merge to form the neutrons. A neutron star is a compact form of all the collapsed neutrons. When *X* moles of neon and *X*/2 moles of calcium collapsed, they both generate same number of neutrons. Therefore, the neutron stars formed from these two clouds should measure the same amount of mass. But the actual mass of the original clouds from which they were formed differ from each other.

If we calculate the mass of a neutron star as the combined mass of all the neutrons in the star, then the star will have more mass than the mass of the cloud from which it was formed because the cloud is a set of atoms and each atom will exhibit a deficit in mass when compared to the mass of all the particles inside the atom.

Another way of measuring the mass of a neutron star is by considering it as a huge nucleus. It is known that each nucleus of an atom exhibits an amount of deficit in mass due to the binding energy within the nucleus. Because the neutrons are densely packed together within the star, the nucleus will have a tremendous amount of binding energy. The amount of binding energy should exceed that of any known nucleus of an atom. If the amount of binding energy is an indication to the amount of mass that was deficit in a nucleus, then the neutron star will have tremendous amount of deficit in mass. Therefore, the star will measure less mass than the neon or calcium clouds. By whatever means we measure the mass of the neutron star, it is certain that the mass of the star will be different than the object from which it was formed.

Here, we can conclude two things. First one is that the two different clouds of material measuring different amount of mass but same amount of basic particles will result in neutron stars with each having same amount of mass when those clouds were collapsed. Secondly, the mass of the collapsed neutron star will either be more or less than that of the cloud from which it formed.

These two statements are in stark contrast to the conclusions of the Shell Theorem and the definition of mass, which states that the size of the object is irrelevant in the amount of mass or gravity the object measures. But in reality, it appears that the mass of an object does change with the volume of the object as seen in the formation of the neutron star. Why is there a disparity between the mass of two forms of same object with the same amount of material?

When an object collapses to a neutron star, it is no longer relevant from which atom the particles were came from. Many different combinations of different atoms yield the same type of object when they collapse to a neutron star if the total number of basic particles inside the objects yields the same number of neutrons. Then the mass of all those collapsed objects will be same even though the original objects have different amount of mass.

Therefore the mass or gravity of an object does change with the volume of the object. A neutron star and the object from which it was collapsed vary in the amount of mass they measure.

Nuclear Fission and Release of Binding Energy

When an uranium atom was bombarded with a neutron, the atom splits into two smaller nuclei and releases energy. The energy released was termed as the binding energy within the nucleus of uranium atom. The amount of binding energy released was equated to the amount of mass that was deficit in the fission products and the process was termed as nuclear fission [1].

In the nuclear fission, it is important to note that the stored energy is associated with the uranium atom and the deficit in mass is observed in the fission products. The mass deficit and the energy were not part of the same object. When an uranium atom releases the energy, in other words, when it disintegrates or expands in size, then only we observe the deficit in mass. The expansion of the matter inside an object releases the energy and at the same time causes the mass to be deficit in the final products [2].

When particles within a nucleus occupies less space, then the nucleus will have more gravitational self energy and at the same time it will measure more in gravity. A point mass object will have tremendous amount of energy and measures maximum amount of gravity. As the particles separate and occupy more space in a nucleus, the nucleus will have less amount of energy and also measure less in gravity compared to a point size object. The amount of energy an object contains and the amount of gravity that object measures depends upon how densely the particles within that object are packed together. If the particles are spread apart in more volume, then there will be further deficit in the amount of mass that object measures.

Because the neutron star is a compact material, it contains more gravitational self energy and at the same time measures more gravity than the gas cloud from which it was collapsed. Therefore, we can deduce that the gravity of the sun will increase manifold when it collapses to a neutron star or a point mass object.

It is possible to create an uranium atom from the fission products by fusing them together. The uranium atom decreases in size, contains more energy and measures more in mass compared to the fused atoms. There is no loss or gain of matter in this process. It means that the actual object remained the same; we just simply reduced the amount of volume that object occupies.

Either it is an atom or an object, the amount of mass it measures depends upon the volume in which the particles were spread apart in the object.

Relationship Between the Number of Baryons and the Deficit of Mass

Let’s assume four different atoms with different number of protons and neutrons but the total number of baryons (protons and neutrons) as 40. The combination of particles and the mass of the four atoms are given in Table 1. The combined mass of one proton (p) and one electron (e) is almost equal to the mass of a neutron (n). So, we can treat the combination of one proton and one electron equal to one neutron. The first atom in the following table is a normal calcium atom with 20 of each basic particle. Let’s assume the combined mass of all the individual particles is equal to X and the atomic mass of the atom is equal to Y. Due to the deficit of mass inside the nucleus, the atomic mass (Y) will always be less than the mass of all particles combined (X), means $Y < X$.

As shown in Table 1, the total mass of all particles inside an atom remains the same as long as the number of baryons is same. But the actual atomic mass of the atoms will always differ. There is no particular pattern in the change in value of the atomic mass. Any one of the atoms, like potassium, argon or chlorine could measure more than the calcium atom. In the same way, any one of those atoms could measure less atomic mass than the calcium atom. This implies that the amount of mass deficit doesn't depend only on the number of basic particles inside the atom. There should be some other factor in the atom which influences the amount of mass the atom measures. As seen in the nuclear fission, a compact form of particles exerts more gravity than when the same particles were spread apart within the atom. It means, the way the particles are grouped together influences the amount of gravity they exert. Therefore, we can say that the atom in which the baryons are packed together in a smaller volume will have less deficit in mass compared to the atom in which the particles were occupied more space in the nucleus. The cause for the deficit of mass has a physical form; that is the structure of the nucleus and not just the notion of binding energy. If we ever peer into the nuclei of different atoms, it is difficult to say which of those atoms contains more binding energy as described in the present principles of physics. We could only see the number of basic particles and how far away they were placed from each other.

Different atoms with Protons(pr), electrons(el) and neutrons(ne)	Number of baryons	Combined mass of particles (grams) (assume $n = p + e$)	Atomic mass (grams)
Atom 1: 20pr,20el,20ne (normal calcium atom)	40	X	Y
Atom 2: 19pr,19el,21ne (Potassium isotope)	40	$X + n - p - e = X$	$Y \pm a$
Atom 3: 18pr,18el,22ne (Argon isotope)	40	$X + 2n - 2p - 2e = X$	$Y \pm b$
Atom 4: 17pr,17el,23ne (Chlorine isotope)	40	$X + 3n - 3p - 3e = X$	$Y \pm c$

Table 1: Atomic mass of different atoms with a fixed number of baryons

If the number of particles and the distance between them is known for a given atom then it should be possible to calculate the mass of the atom instead of measuring it.

When different atoms with the same number of baryons collapses to point size objects, all of those objects will be similar in all aspects and exert same amount of gravity to the earth. But each of the original atoms will measure different amounts of mass due to the structure of the atoms.

Mass Deficit at the Object Level

The way we measure the mass today is external to the object. It doesn't describe the amount of energy an object contains. The gravity of an object to the earth changes with the size, shape and the orientation of the object towards the earth along with the distance [2]. The gravitational self energy within the object depends upon how close the particles are grouped together within the object. There is no truth in the mass-energy equivalence principle.

Mass was defined as the resistance of an object and it was assumed as a fixed amount for a given object. Definition of mass and its measurement using the balance scale was in use even before the discovery of building blocks of the matter. Same amount of these building blocks (baryons) with different combinations has the ability to alter the amount of gravity they measure. On the basis of the Newtonian principle of gravity, Shell Theorem concludes that the gravity of an object doesn't change with the size of the object. But the gravity at the particle level doesn't appear to be following the Newtonian principle. Same amount of baryons in different atoms exert different amount of gravity. Objects are made of particles. If the Newtonian gravity is not in effect at the atomic level then the possibility of the same being in effect at the object level is none.

The inverse square law of gravity was derived with the assumption of gravity as a field emanating from a point source similar to the light spreading all around from a point. The foundation for the inverse square law is that the gravity doesn't depend upon the size of the object. A huge object like our star, the sun, was compressed to a point size and shown that gravity is inversely proportional to the distance between the objects because the intensity of light decreases as inversely proportional to the square of the distance between the objects. If the sun collapses to a neutron star then the amount of mass it measures will increase, ultimately affecting the gravity between the sun and earth. Even if there is a slight variation in the gravity between objects with the change in size then that will invalidate the inverse square law of gravity for objects. Newtonian gravity is in effect neither at the particle level nor at the object level. All the observations can easily be explained with the proposal of gravity at particle level as being inversely proportional to the distance between the particles [2].

In any object, the total mass of all particles will be equal to the measured mass of the object plus the mass deficit.

Total Mass of an object = Measured amount of Mass + Mass Deficit

At the present, we are simply aligning the mass of an object with gravity and measuring it using the balance scale. The deficit part of the mass within the object is completely ignored. When a set of particles occupy certain amount of volume, like particles in an atom, then there will be a deficit in the amount of mass that atom measures. Again, there will be further deficit of mass when a set of atoms form as a molecule, like the molecule of oxygen with two atoms, in addition to the deficit in each of the individual atoms. The amount of mass deficit depends on the distance between the atoms within the molecule or unit cell. This additional mass deficit will exist even if the atoms of same element were grouped together like two atoms of iron. As more and more molecules, atoms or unit cells occupy more space in an object, the combined deficit will further increase. Eventually, an object of one centimeter cube will have more percentage of deficit of mass compared to a single atom. The deficit of mass will increase as the object grows bigger in size.

A cloud of gas or dust will have even more deficit in mass. It is similar to the decrease in resultant force as the angle between the individual forces increases. A ring kept around the earth will stay in place. The gravity of the ring will be zero hence it has zero measured mass. All of its mass becomes deficit because each pair of particles on the opposite side of the ring are placed at 180^o apart, therefore their combined gravity becomes zero. The deficit of mass in an object is not an indication to the amount of energy an object contains. Even though the total mass of a ring becomes deficit, it will have more energy than a cloud of dust made from same amount of material within the ring. Another important point to note in regard to the deficit in mass in the ring is that there is no release of energy equal to the amount of mass that was deficit in the ring. An object will have a zero deficit of mass; means the combined mass of all the particles will be equal to the mass of the object when that object collapses to a point size similar to the resultant force becoming equal to the sum of all the individual forces when all the forces acts in a line in the same direction.

The gravity of the earth on one kilogram iron bar at the surface of the earth is weak because the entire material within the earth is pulling the iron bar in a wide angle. If the earth ever collapses to a point mass then the same point size earth will exert tremendous amount of gravity on the object kept at the present surface of the earth.

Measurement of Avogadro Constant

The concept of mole or Avogadro constant (N_A) gives us an impression that the number of atoms of an element inside an object will measure the same amount of mass irrespective of the amount of space those atoms occupy. It basically makes the size of the object irrelevant in measuring the mass of the object.

The prevailing procedure for the measurement of N_A is as follows. The volume of a single unit cell will be determined using the x-ray crystallography and then the number of such cells will be calculated in one cubic centimeter volume. By applying the data for the density, molar mass and the number of atoms in a cell, the value for the Avogadro number is calculated.

Volume of a single unit cell of an element = v cm^3
Number of unit cells in one cubic centimeter = $1/v$
Number of atoms in a unit cell = n
Number of atoms in one cubic centimeter = $(1/v) * n = N$ *atoms/* cm^3
Molar volume = Molar mass/Density = V_m cm^3
Avogadro number, $N_A = (V_m * N)$ *atoms/g-mole*

Following are the characteristics of the Titanium used to derive the Avogadro number [3].

Unit cell volume for the Titanium = $(3.306 \times 10^{-8})^3$ cm^3
Number of atoms in a body centric unit cell = 2
Molar mass = 47.88 g
Density = 4.401 g/cm3

By applying the above values, we get the value for N_A as 6.02×10^{23} atoms/g-mol. Instead of atoms/g-mol, it is appropriate to name the constant as atoms/molar-volume. In the above procedure, we basically calculated the number of atoms in a given volume. The above derivation doesn't establish any relation between the grams and number of atoms in an object. The molar mass and the density were simply used to derive a certain volume. This derived volume was used to measure the number of atoms depending upon the size of the unit cell and the number of atoms in each cell. The assumed relationship between the molar mass, density and the molar volume doesn't exist in reality. The same object with same number of atoms will measure different amounts of mass depending upon the size, shape and the orientation of that object towards the earth. Therefore the Avogadro constant, an object of molar mass containing a fixed number of atoms, is simply a myth. It is no wonder why we don't have a precise value for this constant.

Conclusion

The mass or gravity of an object depends upon the amount of space the particles occupy within that object along with the total number of basic particles in the object. A nucleus exhibits deficit in mass when there is an increase in the amount of space the particles occupied. The inverse square law doesn't apply to the gravity. The root cause for the observed galactic orbital velocity [4] at the outskirts of a galaxy and the Pioneer anomaly [5] is the present definition of mass. Gravity of an object also increases as it starts to appear smaller in size as the sun viewed from outskirts of the solar system. Even though the gravity of the sun is weak at these depths, all the gravity works in a line making it stronger than normal. Gravity between objects will increase as the angle of projection decreases.

Gravity between two spherical objects separated at a distance of one meter with each having one cubic meter in volume will increase tremendously if those two objects were collapsed to a point size objects. Gravity is a strong force when the objects interacting are of point size and most probably it is the strong nuclear force itself. Inconsistency between mass, gravity, size and energy of an object made the single fundamental force to appear in many different forms such as gravity and strong nuclear force. By the time the strong nuclear force was discovered, gravity was a firmly established theory based on the then prevailing fundamental concepts. Because the newly discovered force was stronger than the gravity, it was assumed that the new force was altogether a different force. The new force was then formulated with its own principles. Formulation of the same force with different equations made the unification of these two forces very difficult. Theory of everything or the unification of fundamental forces is nothing but discarding the ambiguity in the definition of mass. It is also the simplest, most logical and rationale solution for innumerous other anomalies prevailing in the field of physics.

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