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 fixed irrespective of the size of the object. If our understanding of mass is flawed then the whole physics dependent on it will turn out to be meaningless. An object exhibits deficit or gain in mass when there is a change in the volume of that object. A neutron star measures more mass or gravity than the gas nebula from which it was formed. 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 the volume in which the particles were occupied.*

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

Mass of two objects is the cause for the gravity between them. So, the mass deficit can also be described as the deficit in gravity between two objects. 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 resistance to change in motion. It is a fixed amount for a given object irrespective of the volume of the object. And also, each gram of an element will have a fixed number of atoms. It means, even if we compress an object, the amount of mass it measures and the number of atoms it contains remains same. This relation should hold true as long as the amount of matter in an object remains same. Does an object measure the same amount of mass even if we compress that object to a neutron star?

Mass of a neutron star with "*n*" number of neutrons

What would be the mass of a neutron star with "n" number of neutrons? The only way 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 neutron 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 the cloud got ejected when those 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, means 20 of each individual particles. 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. 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 the 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 the neutron star as the combined mass of all the neutrons in the star, then the neutron star will have more mass than the mass of the cloud from which it formed because the cloud is a set of atoms. Each atom will exhibit a deficit in mass when compared to the mass of the total particles inside the atom. Therefore the cloud will measure less mass than the total mass of the particles in the cloud.

Another way of measuring the mass of the neutron star is by considering it as a huge nucleus of a heaviest atom. Each nucleus exhibits an amount of deficit in mass due to the existence of binding energy within the nucleus. Because the neutrons are densely packed together within the star, the nucleus will have 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 then the neutron star will measure less mass than the neon or calcium clouds. In any case, it is sure that the mass of the neutron 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 collapsed. Secondly, the mass of the collapsed 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 material is irrelevant in the amount of mass or gravity they measure. But in reality, it appears that the mass of an object does change with the volume or size of the object as seen in the formation of neutron star. Why there is disparity between the mass of two forms of same object with same amount of material?

When an object collapses to a neutron star or a point mass, it is no longer relevant from which atom the particles came from. Many different combinations of different atoms yield same object when they collapse to a point size object if the number of each type of basic particles inside those objects are same. Then the mass of all those point objects will be same even though the original objects have different masses.

Mass and the balance scale, the equipment used to compare the mass of two objects, were defined and in use even before the discovery of the building blocks of matter. Same amount of these building blocks (basic particles) with different combinations has the ability to alter the amount of gravity they measure. When an object is compressed towards the point size, these same basic particles within that object forms in different combinations and hence will measure different gravity with each of the combinations. A bunch of fifty helium atoms forms as different atoms before finally turning into an isotope of a heaviest atom such as uranium when compressed or fused together. The uranium atom itself will turn into neutron core when compressed even further. All these combinations of particles will differ in the amount of gravity they measure. From these observations, it appears that assuming the size of an object irrelevant in measuring the mass or gravity is a huge mistake.

On the basis of the Newtonian principle of gravity, shell theorem proves that the gravity of an object doesn't change with the size but the gravity at the particle level doesn't appear to be following the Newtonian principle. 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.

Inverse square law of gravity was derived with the assumption that the gravity as a field emanating from a point source just like the light spreading all around from the point source. The foundation for the inverse square law is that the gravity doesn't depend upon the size of the object. Huge object like the sun was compressed to a point size and shown that the gravity is inversely proportional to the distance between the objects. Sun will turn to a neutron star if we ever compress the star. The amount of mass it measures will change, 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 of the objects then that will invalidate the inverse square law of gravity.

Nuclear fission and release of binding energy

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

Here, the stored energy is associated with the uranium atom and the deficit in mass is associated with the resultant products. It is clear that the mass deficit and the energy will not be associated with the same object. When uranium atom releases the energy, in other words when it disintegrates or expands in size, then only we will observe the deficit in mass. Expansion of the matter inside an object releases the energy and causes the deficit in mass that object measures.

When particles within a nucleus occupies in less space then that nucleus will have more 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, that nucleus will have less amount of energy and measures less in gravity compared to 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. A gas cloud measures less gravity compared to a neutron star formed from the same amount of material in the cloud. The same neutron star measures less gravity compared to a point size object formed from the same amount of material.

Measurement of Avogadro Constant

Concept of mole or Avogadro constant ($N_{\boldsymbol{A}}$) gives us an impression that the number of atoms of an element inside an object will measure 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 the N_A is as follows. 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 [2].

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 the atoms/molar-volume. In the above procedure, we basically calculated the number of atoms in a given volume. Above derivation doesn't establish any relation between the grams and atoms. 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 assumption of the mass of an object as the product of density and volume is the main issue in the above derivation. As the object grows bigger in size, in other words if the object occupies more in space then that object exhibits more deficit in mass compared to smaller objects made from same material. As a result, the density (mass/volume) of the bigger objects will be less than the density measured for small objects made from the same material. For example, the density of a ten cubic meter iron sphere will be less than the density of one cubic meter iron sphere. Product of standard density (mass measured for one cm^3) and the volume of an object don't yield the mass of that object. The value derived for the Avogadro constant will be different when different objects are used made out of different elements. It is no wonder why we don't have a precise value for this constant. With the same number of atoms, an object exerts different amount of gravity depending upon its size. Mass measured in grams for an object and number of atoms within that object has no fixed relation to each other.

Relationship between the 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 + neutrons) as 40. The combination of particles and the mass of the four atoms are given in the Table 1. Combined mass of proton (*p*) and electron (*e*) is almost equal to the mass of the 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 the normal calcium atom with 20 of each basic particles. Let's assume the combined mass of all the individual particles is equal to *X* and the atomic mass of the atom as *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 $Y < X$.

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 in different atoms with number of baryons as 40

As seen in the above table, as long as we keep the number of baryons same within the atom, the total mass of all particles remains the same. But the actual measured 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. It means the amount of mass deficit doesn't depend on the number of basic particles inside the atom.

As seen in 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, the only possibility here is 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 occupy 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.

When different atoms with 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 amount of mass due to different value for the deficit of mass in each of those atoms.

Mass deficit at the object level

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

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 mass. 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. 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 and atoms occupy more space, 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. 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. 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. Deficit of mass 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 way we measure the mass today is external to the object. It is in no way describes the amount of energy the 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 [3]. The self energy within the object depends upon how closely the particles are grouped together within the object. There is no truth in the mass-energy equivalence principle.

Conclusion

The mass or gravity an object measures depends upon the amount of space the particles occupy within that object. A nucleus exhibits deficit in mass when there is an increase in the amount of space the particles were occupied. Gravity doesn't appear to follow the inverse square law. The root cause for the galactic orbital speeds and the Pioneer anomaly is the present definition of mass.

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 compressed 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, energy and the number of atoms an object contains made the single fundamental force into 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. Because the newly discovered force was stronger than the gravity described in the prevailing theories, it was assumed that the new force was altogether a different force. From then it became very difficult to unify these two forces. Theory of everything or the unification of fundamental forces is nothing but discarding the ambiguity in the definition of mass. It is the simplest, most logical and rationale solution for the innumerous anomalies in the field of physics. Even the data supports that the definition of mass is incorrect; we are just interpreting the data in a wrong way.

References

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