Reference Frames, Negative Velocity, and the Uncertainty Principle

by

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In this article I explore Heisenberg's uncertainty principle as a vehicle for understanding the relationship between objective reality and subjective reality. This helps to clarify how the observer participates in experiment and measurement. I identify the absolute and relative reference frames in physics. Then I consider the physics of extremely slow relative velocities in the light of relativity theory and quantum mechanics. I also explore ways to interpret "negative" velocity and aspects of velocity that have major importance in understanding the dynamics of rotating galaxies, black holes, relativistic particles, and superluminal phenomena.

Heisenberg's uncertainty principle derives from the reciprocal interdependence of various physical parameters. For example, the change in position of a particle is bound up with its momentum in the following quantum relation

* $(\Delta p)\ (\Delta x) >= \hbar$. ($\hbar$ represents "h bar", 1.054x10^-34 J-s.)

Momentum is mass times velocity. Planck's constant is a minimum quantum unit of "momentum-displacement" or "energy-time" or "angular momentum" that Max Planck first discovered while studying blackbody radiation. Heisenberg's relation puts no limits on either the momentum or the displacement, but says that there is a minimum resolution gap such that the product of the two must be at least the size of Planck's constant. Thus the two component parameters have a reciprocal relation. If you narrow the resolution of one parameter, you lose resolution on the other one. This prevents physicists from ever attaining their cherished goal of precise prediction. The observer's act of measuring the initial conditions changes the initial conditions in an unpredictable way that he can never recover without making another measurement, which again alters the new initial conditions in an unpredictable way, and so on. Therefore the "future" is "knowable" only as a statistical probability.

The theoretical limits for the range of displacement seem to be zero on the low end and the diameter of the universe on the high end. Although velocity is limited by the speed of light, momentum has no such precise upper limit. Its theoretical limits seem to be zero on the low end and the light-speed mass of the universe on the high end.

* $(\Delta p\text{-max}) = (Muniv)\ (c) = (Euniv)\ /\ (c)$.

The actual physical cutoff limit for momentum is, of course, far below that, although one might imagine a single electron (or even a galaxy) heading away from the rest of the universe at nearly light speed. The relative momentum of the rest of the universe would be pretty close to (Muniv c). However, it seems much more likely that the universe curves in on itself by subjecting itself to **asymptotic limits**.

Suppose we have a proton (Mp) that is somewhere between the locations x = 0 to x = 1x10^-10 m at time t = 0. The minimum uncertainty in the proton' s velocity is therefore approximately:

* 1.054x10^-34 kg m^2 s^-1 / (10^-10 m)(1.67x10^-27 kg) = 631 m/s.

The photon that must interact with the proton in order for an observer to "see" it at that spatial resolution accelerates the proton to at least 631 m/s faster (or slower) than its prior velocity. Suppose that we narrow the gap in which we try to pin down the proton' s location, reducing it to 10^-17 m.

* 1.054x10^-34 kg m^2 s^-1 / (10^-17 m)(1.67x10^-27 kg) = 6.31x10^9 m/s.

The proton' s minimum velocity uncertainty -- just the minimum difference in velocity -- now appears to be faster than the speed of light. If the proton was at rest relative to us when we looked at it with this level of resolution, we had to hit it with such a high-energy photon to see it that the proton is now going close to light speed. If it was going at that speed, then we at least stopped it, and perhaps even caused it to recoil. As the proton pushes into relativistic speeds, its mass starts to change appreciably, so we can no longer treat the mass as a constant. We have to add a relativistic term to our mass that adjusts it according to its relative velocity. In other words, a certain minimum portion of the momentum must take the form of a relativistic increase in the mass of the proton so that its relativistic speed stays below (c).

* Mprel = Mp / (1 - (v/c)^2)^1/2).

However, since the proton rest mass (Mp) remains constant, we can move it over to the "constant" side of our relation and put it together with Planck' s constant.

* (Δx) [Δv / (1 - (v/c)^2)^1/2)] >= ħ / Mp.

Since our speed (v) is relativistic, we can write it as a fraction (f) of (c).

* $$\Delta f\, c / (1 - (f)^2)^{1/2} = c\, (\Delta f / (1 - (f)^2)^{1/2}).$$

We use (Dg) as a token to represent the whole expression (Df / (1 - (f)^2)^1/2). Theoretically this number (Dg) can take any value we like that is greater than zero and less than infinity, and it's just a dimensionless number that tells us about the velocity relative to (c). Our number (Dg) has the value of unity when f = +/- (.5)^.5 = +/- .7071.... Note that (f) can be either positive or negative, implying positive or negative velocities. Negative values of (Dg) produce imaginary values of (f), and we will not play with those in this article. But (c) is a constant, so we can extract it from our Heisenberg relation's left side and move it over to the right side.

* $$(\Delta g)\, (\Delta x) \geq \hbar / M_p\, c.$$

It turns out that the cluster of constants that we now have on the right is the Compton radius for the proton, (2.1x10^-16 m). It is also known as the proton's deBroglie radius. This is one of several universal quantum mechanical ratios that describe constant units of distance.

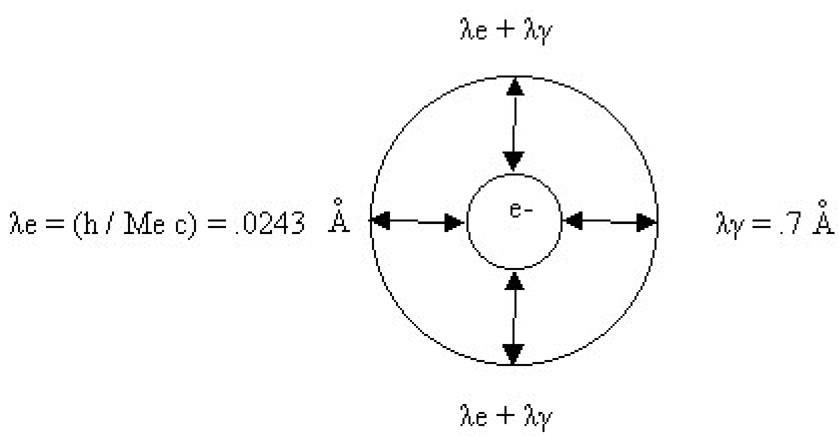
The Compton/deBroglie wavelength for the proton is 1.32x10^-15 m. The electron's Compton/deBroglie wavelength is 2.43x10^-12 m, and its Compton/de Broglie radius is 3.86x10^-13 m. So by studying Heisenberg's relation we discover that the displacement (Dx) for a proton (or an electron) will always be a reciprocal of (Dg) that is quantized by the respective Compton/de Broglie radius (or wavelength.)

In 1923 A.H. Compton discovered the particular wavelength constant that bears his name while studying the behavior of X-rays scattered by graphite. Compton noticed that the radiation leaving the graphite had two intensity peaks, the original wavelength plus a shifted wavelength. The shifted wavelength depended on the angle at which the graphite's electrons deflected the photons. Here (Me) is the electron rest mass, (theta) is the angle of deflection, and (h = 2 pi h-bar) is Planck's constant for wavelengths.

* $$(\Delta\lambda) = (h)(M_e\, c)^{-1}\, (1 - \cos\theta).$$

The energy of the X-ray is so high compared to the kinetic energy of the electron that the electron appears to be relatively in a free state and at rest. The high energy of the X-ray kicks the electron out of its orbit, ionizing its atom. At 0 degrees and 180 degrees (cos th) = 1, so (DL) becomes zero and the Compton shift is null. Under these conditions (no influence or exact reflection) the photon wavelength obviously does not change and the outgoing (scattered) photons look just like classical Rayleigh scattering (i.e. no change in wavelength.) But at 90 degrees (cos th) becomes zero and we see the photons shifted by the pure Compton wavelength of (h / Me c) = .0243 angstroms. At in-between angles the dominant Compton shift becomes a mixture according to the (1 - cos th) relation. This tells us that the wave front of the photon (which is normal to the photon trajectory) has encountered the wave front of the electron' s light-speed momentum (as if it also were a "heavy photon"). The electron thereupon emits (scatters) photons that mirror its own characteristic wavelength of (h / Me c). In 1924 Louis de Broglie discovered this wavelength property of all particles as the logical explanation for the Compton relation. These matter-wave photons move normal to the incoming photons. This mixing of photon wavelengths is an example of phase conjugate four-wave mixing. The photon wave functions scatter at all angles forming a bubble in which the wavelengths of the photons and electrons are entangled in various ratios described by the Compton equation. We now understand that photons and electrons have both particle and wave natures. We can look at the interaction of photons and electrons as particles scattering or as waves interfering.

The wave-mixing bubble looks something like the following schematic diagram, where (Le) is the characteristic electron wavelength and (Lg) is the incoming photon wavelength. The most intense wavelengths depend on the angle of the incident photon as it interacts with the electron: (DL) = (1 - cos th) (h) / (Me c).



The similarity of this relation to billiard ball interactions convinced physicists that radiation comes in discrete quantum packets that came to be known as photons.

The photoelectric effect also lent strong credence to the idea of photons. The photoelectric effect occurs in the ultraviolet spectrum and up into the X-ray spectrum.

Bound electrons absorb the radiation and become energized to the point where they leave their orbits. The effect has a low-frequency cutoff point (e.g., 5.6x10^14 Hz for sodium) below which no electrons will emit, no matter what the intensity of the light. This happens when the energy of the individual photon drops below the potential necessary to push an electron out of its orbit around an atom, thus suggesting that radiation comes in little packets of energy.

Bound electrons tend to absorb low energy photons such as occur with visible light and usually remain bound (except for some weakly bound conduction electrons). They merely shift to more energetic orbits. The atoms absorb the photon momentum. In the low frequency ranges there is a tendency for Rayleigh scattering to occur. This is the usual situation in our atmosphere with the blue spectrum and gives our sky its bluish tint. In Rayleigh scattering the electrons re-radiate incident photons with no wavelength shift. The photon energy is too low compared to the electron, and just "bounces" off. Infrared and microwave photons merely jiggle or twist the atoms they hit because their energies are lower still.

The Compton shift has a cutoff frequency in the X-ray spectrum. Below that frequency the Compton scattering does not occur, only Rayleigh scattering or other forms of interaction. The Compton effect dominates in the gamma region, ultimately giving way to pair production at very high energies. In Compton scattering the electron only absorbs a portion of the photon' s energy, and the remaining energy **scatters** the photon away from the electron at a specific angle and with a specific altered wavelength. The scattered photon exhibits its lower energy by having a longer wavelength.

The Compton shift, or difference between the wavelength in and wavelength out, depends only on the angle of photon deflection. But the quantum energy difference is controlled by the mass of the electron in the universally constant ratio (h / Me c) which is actually the de Broglie wavelength of the particle of matter. High-energy photon interactions with protons follow the same scattering pattern as electrons, but have a shorter Compton/de Broglie wavelength, indicating a higher frequency range required for the much greater proton mass. The cross sections for photon interactions with different materials vary somewhat, especially depending on the tightness of the electron bonds. Theoretically the Compton effect occurs with high-energy photons scattering off any quantum particle and gives a different characteristic wavelength according to the mass of each particle, but it is really only practical to study it with stable charged particles such as electrons and protons. Nevertheless the universal quantum de Broglie wavelength relation (h / Mo c) holds for all particles. So we will refer to the relation as the de Broglie relation.

All stable matter that is made of atoms will have a rest mass that is some whole number (N) multiple of the average rest mass of the proton/neutron quantum particle. Thus we can represent Heisenberg' s relation more generally in terms of the de Broglie relation for protons.

* $(N)(\Delta g)(\Delta x) >= h / Mp\ c.$

What is the value of (N)(Dg)(Dx)? This depends entirely on the viewpoint of the **observer.** Once the observer decides the value of any two components, the universal de Broglie constant (h / Mp c) determines the minimum value of the third component. The de Broglie relationship is all that objective Nature knows about the scattering of photons with particles, the process we call "observing". It is precise, unambiguous, certain, and universal. The number of nucleons, the displacement, and the velocity factor are observer-determined variables. Whether we look at the radius or the wavelength is also an observer decision. These two expressions represent the same thing described from viewpoints that differ by a factor of 2 pi. Although we can think of the electron as a more primitive particle than the proton, the proton "ensemble" is the anchor for stable mass. (For analysis of the relation between electrons and protons, see my article, "Energy from Electrons and Matter from Protons", available at dpedtech.com.)

The observer is entirely responsible for the "uncertainty" in Heisenberg' s uncertainty relation. Nature is not uncertain. It just is. The de Broglie relation that is embedded in every particle of matter shows us the unchanging precision of "objective" Nature. From this viewpoint "absolute" Nature always "observes" the particle just as it is. The relative observer has to make up his mind what he is observing. Only then does the "subjective" side of the relation take shape. The purely "objective" physical world only knows the de Broglie relation. The left-hand side of our equation (as we have written it) is the observer' s **interpretation** of the de Broglie relation based on a particular viewpoint angle. So that is how the observer sees and experiences and measures the situation.

So far in our discussion we have only presented material that you can find in the usual textbooks, but with two important differences. First, we have derived the relationships in a different way. Second, and most importantly, we have shown that

Heisenberg' s uncertainty relation actually involves the interaction of six parameters, three of which are universal constants that define the objective reality and three of which are variables that the observer must define in order to describe his personal experience of subjective reality. The three universal values are Planck' s constant (h), light speed (c), and proton rest mass (Mp). The three relative values are the number of proton masses (N), the dimensionless velocity factor (Dg), and the spatial displacement (Dx).

Let' s play with the relation a little bit. If (Dg) is around 10^-2 (corresponding to a near-relativistic velocity of just under .01 c), then the minimum uncertainty in the radius will be around 2.1x10^-14 m. This is in the range of a proton radius. Moving down to look inside the proton radius requires extreme relativistic velocities. Greater and greater velocities require more and more energy.

Thus it is clear that there is a cutoff point where we simply can not look at any finer detail of particles (under the ordinary rules of physics) without access to tremendous amounts of energy. Any attempt to do so pits us against the increasing relativistic inertial mass of the proton. This is the problem that is commonly encountered in the physics of the subatomic realm and a great headache for builders of particle accelerators.

Now suppose that, instead of a proton, we use the Union Boson particle (Bu = 1.86x10^-9 kg) as our rest mass in the de Broglie relation. (See **Observer Physics** or "Energy from Electrons and Matter from Protons." The Bu particle, which is the "vacuum precursor" of the proton, has a mass about the size of a flea. It is the seed from which the universe grew. No isolated Bu particle remains to be seen from our current space/time viewpoint of the universe, but virtual binary Bu pairs are quite common in our bubbling vacuum. They recapitulate the "Big Bang" every moment and generate protons and neutrons, the building blocks of "stable" matter. Let' s calculate the minimum de Broglie radius of a Bu "particle".

* $(\Delta x)(\Delta g) >= h / Bu\, c >= 1.888\text{x}10^{-34}$ m.

Since this relation is already at the Planck scale, any value of (Dg) above 1 causes (Dx) to drop below the Planck scale and disappear inside the universe' s black hole event horizon that is defined by the Planck radius. If (Dg) exceeds 1, then the (Dx) for a Bu particle (or anything larger) can never be measured with any instrumentation belonging to this physical universe. (This is not surprising since a Bu particle represents the seed of the whole universe.) So we can disregard such displacements in ordinary physical measurements. The mass of the Bu particle is the **crossover point** between the microscopic realm and the macroscopic realm. Anything larger than this scale behaves according to the usual laws of classical physics. Nevertheless we can extract a mathematical value for the displacement indirectly by finding out the value of (Dg). Then we just calculate the quantum reciprocal using the de Broglie relation as our fulcrum.

For example, if we use a rest mass of 10 kg, then we get:

* $(\Delta x)(\Delta g) >= h / (10\ kg)(c) >= 2.2x10\text{^-}43\ m.$

Let' s say that a projectile with a mass of 10-kg is moving at 30 m/s. Thus (Dg) will be around 10^-7, and the displacement uncertainty (Dx) will be around 2.2x10^-36 m, which is below the Planck scale. Any macroscopic object moving at a non-relativistic velocity has virtually no (Dx) uncertainty unless you focus in on its finer structure below the scale of the Bu particle. As soon as you zoom in to look at an object' s microscopic structure, you change the scale of your observer viewpoint and see the object jiggling all over the place. Once again, the level of uncertainty depends entirely on the observer' s viewpoint and not at all on the object. The object by itself just is what it is, and can be defined in terms of universal constants. Who defines the universal constants and how this is done are interesting questions that I take up in detail in **Observer Physics**, ch. 13, and in an article entitled "Quantum Foam, Snow White, and the Seven Dwarves." (See dpedtech.com.)

Now let' s consider in more detail the case where the velocity gets **very** small. From the conventional viewpoint this will not affect the rest mass in a relativistic way. Going to slower velocities brings us closer to the rest mass, -- right? However, Heisenberg' s relation tells us that if an object' s velocity gets **very** close to zero, the position gets very unclear, regardless of the mass of the object. We select a particular (rest) mass (Mo) and then hold it constant while we study the object at various slow velocities.

* $(\Delta v)(\Delta x) = \hbar / Mo.$

Suppose we are studying a top with a mass of 1 kg. Since we let the top spin in free space with no gravitational influences from outside it, it will not precess. Its central axis will be relatively motionless compared to any other point on the top. Of course, we only know it is spinning by virtue of comparing it with some reference point that is independent of the top and its motion. If the velocity at the center of mass gets down to relative perturbations of 10^-50 m/s, then the radial displacement value of (Dx) will be almost 10^8 m or more. The minimum central region of the top will seem to expand to almost one light second in radius. The top' s center has become non-local and spread out in space. The top' s nearly motionless center of mass becomes indistinguishable from the free space vacuum state that surrounds it.

This suggests that we can represent (Dx) as (Dct), where (c) is light speed and (t) is time in seconds. The expression (Dct) is a spatial displacement in meters.

Now we can extract another (c) and move it to the other side of the equation. This gives us the following uncertainty relation for a single proton,

* $(\Delta g)(\Delta t) >= \hbar / Mp\ c^2$.

Our general equation then becomes:

* $(N)(\Delta g)(\Delta t) >= (\hbar / Ep)$.

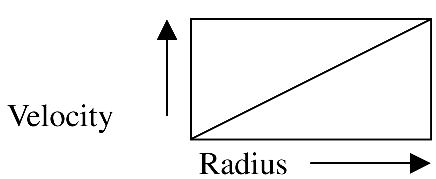
Here (Ep) is the rest mass energy (Eo) of the proton by the Einstein relation (Eo = Mo c^2). So the observer decides the parameters of time, space, and mass (i.e. the number N). We incorporate relativistic time dilation as well via the factor (Dg).

Going back to our slow-moving object, take another look at the rotation and/or perturbation of the center of mass of our top.

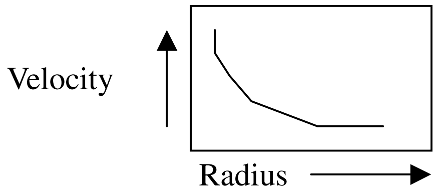
* $(\Delta v)(\Delta \lambda) >= h / Mp = 4x10^{-7}\ m^2/s$.

The $(\Delta \lambda)$ roughly represents one cycle of the top's "center", a single proton.

The ordinary rotation curve for a top would be a linear relation between velocity and radius since the molecular bonds cause the whole structure to move as a single object.



However, the "uncertainty curve" for a free proton (or any other "unattached" object) that is moving in a gravitational orbit is quite different. It is closer to the orbit curve produced by Newton' s law for mean circular orbits.



In Newton' s relation V is the velocity, R is the radial distance between a gravity well and its satellite, G is the gravitational constant, and M is the mass of the gravity well (e.g. a star).

* V^2 R = G M.

For example, in our solar system the sun' s mass is 1.99x10^30 kg. Thus (G M) comes to just under 1.33x10^20 m^3/s^2. The average velocity of an orbiting planet decreases as the planetary orbital mean radius increases. For example, Venus moves at around 3.49 km/s, Earth at 2.96 km/s, Mars at 2.4 km/s, and Jupiter at 1.3 km/s. This is the classic example of the Keplerian Decline. In each case the square of the planet' s velocity times the mean radius of the planet' s orbit comes very close to the value of (G M).

Study the similarities between the relations framed by Heisenberg and Newton. The expression (G M) is a constant -- (G) is universal, and (M) is constant for all orbits around a specific gravity well such as the star that governs a solar system or a planet with a set of moons. The extra V in Newton' s equation simply "distorts" the rotation curve, pulling it closer to the velocity axis. But the curve still has the same basic asymptotic shape and inverse relation between the two variables. As the radial distance gets smaller, the velocity gets larger. As the radius gets larger, the velocity gets smaller.

The key similarities between the relations are the mathematical relations and the dimensions of the variables. The key difference between these two relations is that Newton gives us an "exact" equation from which to predict velocities and radii. Heisenberg' s relation is an inequality that gives us a minimum resolution for comparing the range of change for velocities and displacements. However, when we look more closely at Newton' s equation, we find that it is not really "exact" because a planet can have moons and other satellite objects moving along with it and "fuzzing out" the orbit that it occupies. Newton merely predicts an average velocity at a particular average radius, even for elliptical orbits. For example, the moon orbits the earth while the earth orbits the sun. So the moon orbits the sun in a "fuzzy" earth orbit, and the moon's velocity relative to the sun varies over a range depending on the orientation of its earth orbit to the sun.

The range of velocity for the moon or any other earth satellite relative to the sun will have a certain minimum value that will be less than earth's average velocity when the moon moves exactly opposite the direction the earth moves. Any earth satellite's velocity relative to earth also will depend on the radius of its earth orbit according to Newton's law. A larger lunar orbit with greater radial displacement variance relative to the sun will give less variance from the average earth orbit velocity because the satellite will move slower relative to the earth. A smaller lunar orbit has less radial variance relative to the sun, but greater local velocity variance. This also generates a range of radial displacement and velocity. Thus we end up realizing that Newtonian orbits actually contain Heisenberg-like uncertainty relations. For any range of radial displacement in an orbit due to subordinate orbits there is a minimum velocity range that the subordinate object must have. The uncertainty has the same reciprocal relation. Smaller radial displacement means greater velocity displacement, and larger radial displacement means less velocity displacement.

Like Heisenberg's relation, we have theoretical asymptotes that do not actually extend to infinity, but reach a practical resolution limit. The high-end cutoff velocity for a Newtonian system is either crashing into the local gravity well and merging with it, or the relativistic speed limit per the system's available mass-energy -- usually the former. As the radius grows, the velocity drops off toward an asymptote at zero, but it never exactly reaches that limit. In a Newtonian system the subordinate (lunar) object reaches a point where it no longer functions as a subordinate satellite and sets up an independent (solar) orbit or joins another planet's lunar system.

When we plot our two variables (Heisenberg or Newtonian) on a graph with axes representing velocity versus distance, we see that the curve stays in the first quadrant between the two positive axes. However, the possibility of a negative velocity and/or a negative radius also exists. Ordinarily we think of negative velocity as simply going in the opposite direction from positive velocity. But in our graph we are plotting velocity versus distance. We treat velocity as a separate dimension. Therefore, negative velocity must be something different that is independent of direction in space.

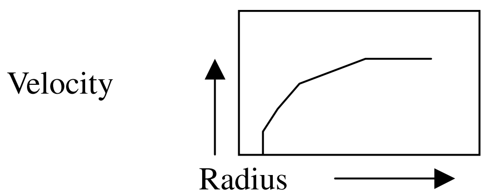
We find a clue by studying the asymptotes that limit the parameters. Positive velocity represents speed increasing toward the limit of (c) or some other limit velocity (such as rim velocity for a rotating system). Perhaps negative velocity represents speed decreasing toward zero or some other minimum asymptote velocity. There is a maximum high-end cutoff velocity beyond which you can not push a mass due to physical limitations of energy available to the system. There also is a minimum cutoff velocity beyond which the motion of an object becomes uncertain due to physical limitations. Kinetic motion is equivalent to temperature, so the slowing of an object to absolute rest is like cooling it to absolute zero Kelvin. As you get closer and closer to absolute zero, it takes more and more energy to cool the object further. Eventually we get to an asymptote requiring unlimited amounts of energy.

So slowing down and speeding up **both** require an input of energy to change the momentum of an object. There is no real difference between acceleration and deceleration other than the observer' s conventional bias. When you hit the gas pedal in your car, you feel pushed backward. When you step on the brake pedal, you feel pushed forward. The hyperbolic curve relating speed and displacement says the **same thing** with respect to energy whichever way you flip it.

Therefore we find that the two asymptotes of speed are mirror images of each other, and speed and displacement have a reciprocal relationship with each other when viewed from the perspective of the "absolute background state" of Nature as defined by the constant relationships. This absolute background is the detached observer frame that Newton was assuming without demonstrating. We can see the absolute frame clearly when we arrange all universal constants on one side of a relation and all variables on the other side. If we place local constants (such as the mass of a stellar gravity well) with universal constants, then we get a local rest frame. But we can always translate local constants into universal constants. For example, we express a star as a collection of (N) proton/neutrons, and (Mp) is a universal constant.

The mirror images of observer generated curves can be reflected at various angles between arbitrary asymptotes, depending on the observer viewpoint and the dynamics of the system. A 90-degree reflection is like the Compton shift that we discussed earlier.

On a cosmic scale galactic rotation curves exhibit a mirror image of the usual Keplerian Decline. As an object nears the galactic center its speed approaches zero as a limit, like the top, but asymptotically. The difference between the two systems, aside from scale, is that the top behaves as a single particle whose component atoms are tightly bound by molecular bonds, whereas the galaxy behaves more like a gas whose component stars are connected only by their mutual gravitational interactions. In the case of the top the relation between velocity and radius is linear. Newton' s formula is a hyperbolic curve with orthogonal asymptotes fencing in both extremes of the curve.



General Shape of a Galactic Rotation Curve

As the radius extends outward in a galactic rotation curve, the velocity increases rapidly from a minimum velocity close to "zero" and then tapers off toward an asymptotic maximum "rim" velocity. As we approach the center of the galaxy, the local orbit velocity of stars decreases rapidly until we can no longer clearly distinguish the exact velocity from random milling around in the bulge. This is not merely due to the resolution of our measuring instruments, although that may also play a role. Objects near a galactic nucleus reach a certain minimum velocity because locally they follow Kepler' s laws and go "faster" with closer orbits while the dynamics of the nucleus tend to "slow" them down. **Thus on a cosmic scale we encounter the same problems of uncertainty that particle physicists deal with at the microscale.** The details differ, but the problem is the same. Not only is there no way to bring an object to a state of complete rest, the closer it gets to the rest state, the smaller the scale becomes. As the scale shifts, there are major shifts in the local dynamics in terms of both relative distance and speed. This amounts to acceleration mixing with deceleration and causes uncertainty.

A galaxy as a whole is a dynamic system with two asymptotes. One is the finite maximum "rim" velocity that corresponds to a local "c" for that system. The other is the finite minimum velocity below which you can not distinguish a fixed velocity for a specific orbital radius. From the viewpoint of energy this slow velocity corresponds to "anti-c" -- it has a 180-degree phase shift in space/time. At one end of the curve the radius grows, but velocity stays almost constant. Then we hit the limit at the rim. At the other end of the curve velocity drops to a low-end cutoff minimum as the radius tapers down to its limit of 1 proton radius at galactic center. The gravitational constant times the total mass constant determines the scale of the curve, and the curve runs between the rim' s high-end cutoff velocity and the low-end cutoff velocity. (Some galaxies hit a maximum velocity at the edge of the bulge and then taper off a bit for stars out near the rim.)

Acceleration and deceleration are the same thing. Both asymptotically approach limits. Suppose we think of slower and slower positive velocities as faster and faster negative velocities. As the negative velocity becomes relativistic, the relativistic mass increases and forces a cutoff due to "negative" energy limitations. This is the mirror image of an object moving faster and faster in positive velocity and approaching the speed of light. However, in this case the observer actually seems to see the positive motion of the object become slower and slower.

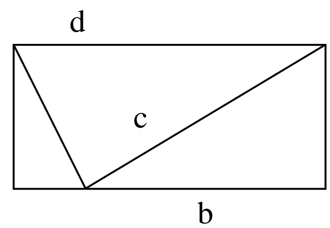
To plot the rotation curve of a galaxy, we simply take the velocity of the star inside the galaxy that we are studying and reverse its sign. As an observer outside the galaxy we see the star moving with the rest of the galaxy. The stellar component of the galaxy rotates in the same direction as the local galaxy region in which it is embedded, relative to the galactic center of mass. However, when we observe a solar system, the central star and the satellite planet seem to go in opposite directions relative to the system' s center of mass because they are on opposite sides of the center. This relative motion is very obvious with binary star systems.

So we formally represent this difference in viewpoint by switching the sign on one velocity in Newton' s equation. It doesn' t matter which one. Since we are used to taking the velocities in solar systems as all positive (even though they are in opposite directions), we have to switch the sign on the velocity of a star in a galaxy. This flips the rotation curve over into its mirror image and gives us the dynamics of the stars that are rotating at various points in the galaxy. For the details regarding how to calculate such rotation curves, see my article, "MOND, Dark Matter, and Observer Physics: Spiral Galaxies," available for download at dpedtech.com.

The asymptotic behavior that we noted in the Heisenberg relation and Newton' s gravitational relation is a common characteristic of many dynamic systems that are constrained by relativity and quantum mechanics. Another famous example is the Einstein relation, Eo / Mo = c^2. This appears to be a linear relationship. But, when we translate this relation into the Einstein-de Broglie Velocity Relation and express all the components as velocities, then it becomes a reciprocal relation. (Vg) stands for group velocity, and (Vp) stands for phase velocity.

* $(V_g)(V_p) = c^2$.

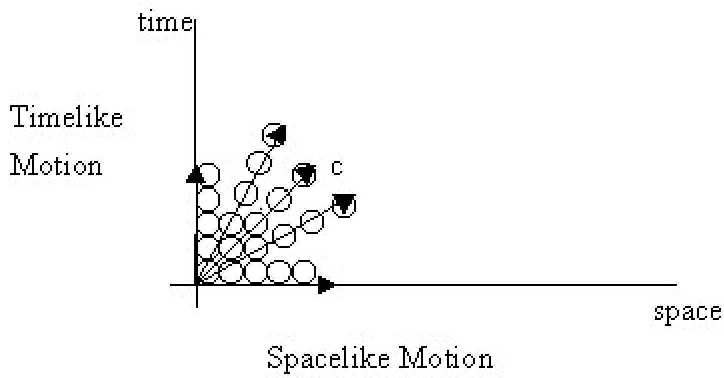
This relation shows clearly why "matter" travels at less than the speed of light. Matter is localized photon energy that forms a wave packet called the "group wave". It has a dispersion relation with a superluminal set of phase waves such that the product of the two velocities equals the constant c^2. We can represent this relation in a very general way as two similar triangles that have the ratios $b/c = c/d$. for pairs of sides. This relationship is also a fundamental characteristic of the Golden Ratio. Thus various incarnations of the Golden Ratio govern the dynamics of galaxies and solar systems as well as wave guides and the microscopic world of quantum uncertainty.



Let' s consider an example that shows the importance of the observer' s relative viewpoint with respect to the asymptotic dynamics of fast and slow velocities. Imagine that we are at a safe distance away from a black hole watching an object fall into the hole. We observe the object' s trajectory as it heads toward the event horizon. But, as we watch from outside, we notice something odd and counter-intuitive. Instead of accelerating toward the huge gravity well of the black hole, the object **decelerates just like an object falling into the center of a galaxy**! The event horizon radius, $R_s = (2GM / c^2)$ for Schwarzschild black holes, acts as a negative velocity asymptote for outside observers. Mathematically it is often called a psuedo-singularity. The observer at a distance can watch the object fall and fall, but it never seems to cross the horizon. It just falls slower and slower until it looks like a postage stamp stuck on the event horizon. To an outside observer it will never cross the horizon. When the object is **at rest** right at the horizon, light "emitted" from it experiences infinite redshift, and infinite time dilation by the relation:

* $d\tau = (1 - 2GM / R c^2)^{1/2} (dt)$.

As the radial distance (R) approaches the event horizon surface (Rs), (d tau) goes to zero. The gravitational pull becomes strong enough that light from the object can not leave the horizon once $(2GM / R)^{1/2}$ equals (c), which is what happens at (Rs). The light remains frozen there for as long as the black hole exists. This is the mirror image of the condition that our physical bodies will never leave the universe, no matter how fast or far we go. Someone who is inside the black hole trying to escape will never make it out with his physical body. The relation (2 G M / R) becomes greater than c^2, so (1 - 2 G M / R c^2)^1/2 shifts into an imaginary dimension. (We can only imagine, not see what happens.) Even something moving faster than light could not escape from the event horizon. The light cone tips over so that light that would normally radiate out away from the horizon only radiates inside the event horizon. Inside the horizon space and time effectively switch places so that each unit of time represents a distance in space.



The above space/time sketch shows five different particle trajectories that begin at the origin. The vertical sequence shows a particle at rest that makes no progress in space over the passage of time. It sits still in one location and is there all the time. The particle with a slow velocity makes some progress in space over a period of time. It looks like a series of frames with little gaps in between. The particle moving at 45 degrees represents a photon moving at light speed. It appears to move in equilibrium balanced in space and time. The particle trajectory that leans below the "light line" represents a superluminal particle. The horizontal "trajectory" shows a particle moving at "infinite" speed. To a timelike observer it looks like a solid line that flashes momentarily. So from the viewpoint of zero velocity an object sits still at a point in space and moves through time. From the viewpoint of infinite velocity an object sits still at a point in time and moves through space. The origin on our graph represents a transcendental point that neither moves in space or time. In terms of our black hole, the light line represents the boundary of the event horizon. Timelike motion represents motion outside the horizon, and spacelike motion represents motion inside the horizon. The origin is like the singularity at the center of the hole.

A particle moving at a superluminal speed looks to a subluminal observer like a line of identical particles rather than a single particle. What we experience as solid matter made of orderly arrays of atoms may actually be single atoms that are propagating as rapid superluminal pulses across a spatial distance. The illusion that an object stays in one location may be due to rapid iterations of the same pulse. The insistence that matter can not go faster than light may ignore the evidence that is right before our eyes. How else could a single Bu-size particle that seeded our universe generate all the trillions of trillions of copies of itself that make up the protons of our physical universe? Perhaps our physical world is really a clever illusion caused by an observer taking a subluminal viewpoint to watch superluminal particles zip around. These clusters of superluminal phase waves look like real objects extended in space.

If someone is riding on an object that falls into the black hole, his experience is quite different from the external observer. He notices that the velocity continually increases and he falls right on through the event horizon toward the singularity at the center of the hole. The realities are radically different for each observer. But to the outside observer the acceleration of the object's inward fall looks just like deceleration to slower and slower velocity until the object comes to a complete stop.

It turns out that the environment inside the event horizon of a so-called "black hole" need not be black at all. It may be a fairly dense cluster of stars at the nucleus of a galaxy. Ohanian and Ruffini calculate (p. 439) that such a cluster of around 10^11 stars, each about the size of our sun, could float around within a space with a radius of a little over .03 light years. The average distance between them would be about the same as the distance between our earth and our sun. The average density would be about a gram per cubic meter. If we increase the number of stars to 10^15 solar masses, then the radius is slightly under 3x10^18 m or about 96 parsecs, still in the nucleus of a galaxy with a radius of many kiloparsecs. This gives us an average density of 1.84x10^-11 kg/m^3 or about 1.1x10^16 hydrogen atoms per cubic meter (5.45x10^15 H2 molecules per m^3). Compare this with our atmosphere of about 4.73x10^-3 kg/m^3. Such a body of hydrogen gas would be 2.5x10^8 times less dense than our atmosphere at sea level. It would be close to our atmosphere right at the edge of space. So the interior of a supermassive black hole gets close to the conditions of empty space. In other words, we live in a very large black hole.

An important point to keep in mind here is that if the component particles of a body have collapsed to a radius smaller than Rs, the body will be "unable to come to equilibrium and will continue to collapse -- the gravitational forces are so strong that nothing can resist them." (Ohanian and Ruffini, p. 439.) However, in the case of a galaxy most of the material remains outside the event horizon. Therefore it remains above the critical density for collapse and is able to achieve equilibrium. The equilibrium results in the low-velocity floating appearance that is observed for stars near the galactic hub.

To an "outside" observer an event horizon acts as a negative asymptote. It becomes an "anti-singularity" due to the illusion of time dilation just as a galactic nucleus does in the case of a galaxy. Although we do not have any handy black holes nearby to observe this phenomenon with, we can watch how stars in a galactic bulge seem to just hover in space without falling into the center. Maybe they **are** "falling" toward the event horizon of a black hole in the center of the galaxy or are just sitting still right on or near the horizon. Their orbital velocity is a reflection of the rate of fall. If a communications satellite loses its orbital velocity (through accumulated drag from occasional collisions with wandering molecules), it falls to earth. So if a star can hover near the nucleus of a galaxy without orbiting, it either must be falling or something appears to hold it there. To us such stars may seem practically motionless because of the time dilation as their photons try to move outward under the gravitational pull of the galactic nucleus. Astrophysicists are accumulating evidence that many galaxies, including our own, harbor one or more black holes at their core. On the other hand, the nuclear stars may actually be floating due to the relative density of the star soup in which they are embedded. I suspect that a combination of these two factors produces the galactic rotation curves that we obtain from observations.

Here is another example of velocity asymptote mirroring. We commonly observe significant time dilation with relativistically moving subatomic particles. For example, the decaying debris from cosmic ray showers travels much farther as it falls through the atmosphere than might be expected based on its rest-frame half-life. The high speed of the particles slows down the clock of such a fast-moving particle. If these cosmic ray particles could move at light speed, they would never "decay". Their clocks would slow to a standstill for outside observers. But earth is not a black hole (except for people who believe they are gravitationally trapped here), so light speed is an asymptotic limit they do not reach unless they convert into immortal photons -- a procedure that changes the dynamics of the system. Instead their decay rate just slows down noticeably.

Do you see the similarity between time dilated relativistic subatomic particles falling to earth, and objects falling "slowly" into a black hole, and stars falling slowly into the center of a galaxy?

At a certain energy density these free falling objects -- **even photons** -- may achieve space/time equilibrium and just float at a certain radial distance from the center of mass. This is what we do on planet earth. We don' t seem to go anywhere up or down, but we are actually in free fall accelerating at 9.8 m s^-2. What keeps us in place is our relative density.

The apparent behavior of the object falling into the black hole -- whether it seems to go faster or go slower or not move at all -- depends on the viewpoint of the observer. Nature only knows the constant relations that hold for all times and places. Therefore our three general principles of observer physics for considering any dynamic system are as follows.

1. A ratio of various universal physical constants defines the objective physical condition of the system in a way that is universally valid.

2. The observer then sets parameters (such as space, time and mass) in order to interpret the behavior of the various aspects of the dynamic system based on his assumption of an arbitrary subjective viewpoint.

3. The subjective interpretation is equal to or is bounded within the tolerance defined by the constant objective relations.

*** (N)(Δg)(Δx) >= (h) (Mp c)^-1.**

These principles assume that the observer has already defined the set of constant relations that controls the asymptotic limits of his particular universe. In other words, prior to the particular behavior of any dynamic system is the assumption of an observer viewpoint, and prior to the assumption of a viewpoint is the definition of a set of constant relations that determines the basic structure and **possible** behavior of a particular universe. Once we have defined the foundation structure of our stage, we can play with the possibilities of actions that may unfold on that stage. (For details about how to define universal foundation structures, see my forth-coming article, "Quantum Foam, Snow White, and the Seven Dwarves" or refer to **Observer Physics**, ch. 13.)

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