CHAPTER 6

ATOMIC ORBITS AND PHOTONS

Mass and Radiation

Quantum of action and Planck's constant

Particle waves and fixed atomic orbits

The Photon

The velocity of light

Only a few hundred years ago Copernicus explained that the Earth is not at rest nor at the center of the Universe, but is moving around the Sun at a tremendous velocity. Copernicus' discovery led to simple calculations which can be used not only for our own solar system but also for atomic orbits and the motion of stars and galaxies. It is understandable however, that our Earth for so long was believed to be at the center of heaven and at rest since we can't feel ourselves hurling through space and from our point of view it certainly looks like all heavenly bodies are moving around us. Today we smile at our ancestors belief not realizing that our text books still teach us a similar doctrine. Modern relativity and cosmology has no problem in placing our reference frame at the center of the Universe and at rest. The harmonic Universe on the other hand, demands that we move with an absolute velocity of c relative to a cosmic center of mass. This opens up a new avenue in physics that present relativity is unable to treat, namely that velocities created by loss of energy differs in magnitude from velocities generated by gain in energy. The harmonic Universe offers answers to many unsolved phenomena. One such phenomenon is the capture of electrons in atomic orbits where energy is lost to radiation.

6.1 Mass and Radiation

It has been stated that mass and radiation are the two basic essentials in Nature. Both represent energy in different forms. Inertial mass equals potential or stored energy whereas radiation equals power or transformation of stored energy to radiation. We have also seen that the increase in energy, ΔE, of a bullet fired from a rifle increases the inertial mass of the bullet by $\Delta m = \Delta E / c^2$. Energy is transferred by radiation from the burn of the powder which itself loses at least as much mass as is gained by the bullet. When the bullet is stopped by a target the inertial mass gained converts back to radiation which heats both the bullet and target. Transfer of energy cannot occur instantaneously but must take place over a certain length of time, Δt. The transfer of radiant energy is measured in power $L = \Delta E / \Delta t$ (watts). Power is carried by individual photons which are massless wavelets or power pulses traveling with the speed of light. Each photon or wavelet is half a wavelength in size and has a frequency of $\nu = \frac{1}{2} L / E$, where E is the energy of the photon.

6.2 Quantum of action and Planck's constant

Chapter 5 section 5.6 describes how energy appears in frequency. It was explained by the fact that we are part of an oscillating Universe in which all matter is subject to the same fundamental frequency ν_0 or ω_0. Energy can therefore only appear in steps of its fundamental frequency just as frequencies of standing waves on a vibrating string only occur in steps set by the fundamental frequency of the string. The simple harmonic motion of the Universe can also be compared to the harmonic motion of a pendulum in a gravitational field. The fundamental angular frequency of a pendulum's to-and-fro motion is approximately

$$\omega_0 = \sqrt{\frac{g}{x}}, \qquad (t^{-1}) \qquad (57)$$

where g is the gravitational acceleration and x the length of the pendulum. However, during its to-and-fro motion the pendulum also sweeps through numerous amounts of secondary frequencies of

$$\omega^{//} = \frac{v}{x}, \qquad (t^{-1}) \qquad (58)$$

where v is the linear velocity of the pendulum that varies between zero and maximum as the pendulum moves from its highest to its the lowest position. The same is true for our Universe where the frequency of the expanding-contracting motion (to-and fro-motion) is

$$\omega_0 = \sqrt{\frac{a_0}{x_0}}, \qquad (t^{-1}) \qquad (59)$$

which corresponds to a circular motion of

$$\omega_0^{//} = \frac{v_0}{x_0}. \qquad (t^{-1}) \qquad (60)$$

For matter at relative rest with respect to our frame of reference at x_0, the linear velocity $v_0 = c$ and circular frequency $\omega_0^{''} = \omega_0$.

The fact that matter at relative rest in our frame of reference has an angular frequency of ω_0 while hurling through space at a velocity of c, is certainly not noticeable to us. It becomes noticeable, however, as soon as its relative rest is disturbed by a change in the absolute values of v_0 since it creates a measurable change in the fundamental frequency ω_0 which in turn changes the rest mass energy E_0. The change of E_0 as a function of change in frequency can easily be determined since the frequency change $\Delta\nu$ of an electron that has gained energy of ΔE relative to our frame of reference as derived from Equation (54) and (55) Chapter 5, section 5.6 is

$$\frac{\Delta E / \Delta t}{\Delta \nu / \Delta t} = \frac{\Delta E}{\Delta \nu} = h, \qquad (ml^2/t) \qquad (61)$$

or in power per unit angular acceleration

$$\frac{\Delta E / \Delta t}{\Delta \omega / \Delta t} = \frac{L_e}{\alpha_1} = \hbar, \qquad (ml^2/t) \qquad (62)$$

where L_e is the power needed to change the electron's angular frequency by $\alpha_1 = 2\pi / s^2$ (angular acceleration) and $\hbar = 1.054495 \times 10^{-34}$ w s^2 is Planck's constant expressed in power per unit angular acceleration. The angular frequency of an electron that has gained an additional energy of ΔE is therefore

$$\Delta\omega = \frac{\Delta E}{\hbar}\ , \quad \text{(radians per second)} \qquad (t^{-1}) \qquad (63)$$

and converting to standard frequency in cycles per second

$$\Delta\nu = \frac{\Delta E}{h}\ , \quad \text{(Hertz)} \qquad (t^{-1}) \qquad (64)$$

where $\Delta\nu$ is frequency in Hz and $h = 6.625590 \times 10^{-34}$ J/Hz is Planck's constant expressed in energy per Hz. Since frequency appears only in even multiples of the fundamental frequency ω_0 or ν_0 the energy of an electron becomes quantized in multiple steps of $E = \omega_0\hbar$ or $E = \nu_0 h$.

6.3 Particle waves and fixed orbits

It has been described how energy appears in steps of frequency, a phenomenon that was empirically discovered by Max Planck in the early part of the 20th century. Planck's discovery was limited to the electromagnetic radiation of photons generated by atomic oscillators. Each time an electron is captured in a lower orbit of an atom, it loses potential energy which is emitted as electromagnetic radiation with a frequency of $\nu = \nabla E / h$, where ∇E is the energy loss involved in the capture process. Since electromagnetic radiation, or photons, propagate through space with *c,* the velocity of light, they can also be assigned specific wavelengths of $\lambda = c/\nu$. In 1924 Loius de Broglie (1924) made the bold suggestion that energetic particles, such as electrons, moving with a velocity of *v*, might also be assigned wavelengths of

$$\lambda = \frac{h}{mv}\ , \quad \text{(de Broglie)} \qquad (l) \qquad (65)$$

a prediction which was closely verified experimentally by Davisson and Germer (1927) and by Sir G.P. Thomson. It was perhaps unfortunate that de Broglie used the particle's momentum $p = mv$ in his theoretical treatment of particle wavelengths since Planck's constant relates to energy and not momentum.

The problem with de Broglie's equation, is that it is a non-relativistic equation and it refers to a particle having a full wavelength when in reality particles, just like photons, only appear in half a wavelength. The fact still remains that de Broglie's theory of moving particles having the same wave character as photons is one of the greatest achievements in quantum theory. The wave character of moving particles has to do with the fact that energy appears in frequency, see Equation 64, and if we divide the velocity of a moving particle by its acquired frequency we obtain its wavelength.

The correct wave equation for particles having gained energy is thus

$$\tfrac{1}{2}\lambda = \frac{\tfrac{1}{2}h\Delta v}{\Delta E} \quad (\tfrac{1}{2}\text{ wavelength}) , \qquad (l) \qquad (66)$$

where ΔE is the particle's gain in rest mass energy and Δv the acquired velocity of the particle relative to our frame of reference.

There is one more twist to the particle wavelength story which has not been considered before, namely that a particle can have two different wavelengths depending on whether the amount of potential energy is lost or gained. This is because the harmonic Universe model predicts different relative velocities for a particle depending on whether it has lost or gained energy. An example of velocities produced by gain in potential energy are particles accelerated in particle accelerators and an example of velocities resulting from loss of potential energy is the capture of electrons in atomic orbits where energy is lost to radiation. The dual energy-velocity relationship predicted by the harmonic or collapsing Universe model (see Chapter 3, section 3.1 Equations (5) and (10)) is here summarized by Equations (67) and (68) and compared to velocity equations based on Newton's law of motion (69) and Einstein's relativity theory (70)

$$\Delta v = \sqrt{c^2 - \left(c \frac{E_0}{E_0 + \Delta E} \right)^2}\ , \quad \text{Collapsing Univ.(Energy gained)} \qquad (67)$$

$$\nabla v = \sqrt{c^2 - \left(c \frac{E_0 - \nabla E}{E_0} \right)^2}\ , \quad \text{Collapsing Univ. (Energy lost)} \qquad (68)$$

$$\Delta v \text{ or } \nabla v = \sqrt{\frac{2 \quad E}{m}}\ , \quad \text{Newton} \quad \text{(Energy lost or gained)} \qquad (69)$$

$$\Delta v \text{ or } \nabla v = c\sqrt{1 - \frac{1}{(1 + [E / E_0])^2}}\ , \text{ Einstein (Energy lost or gained)} \qquad (70)$$

where Δv and ∇v are changes in the velocity of a particle that has gained or lost energy relative to an observer at rest in our frame of reference. E_0 is the particle’s so-called rest mass energy or the absolute energy of matter at relative rest in our frame of reference ($E_0 = m_0 c^2$). ΔE and ∇E represent gain or loss in energy relative to our frame of reference. Both Equation (67) and Einstein's Equation (70) yield the same results for particles which have gained energy while Newton's non-relativistic Equation (69) will deviate more and more as velocity increases.

In atomic orbits where velocities are produced by loss of energy only Equation (68) works while both Einstein's and Newton's equations fall short. The reason for this is that neither Newton or Einstein treated velocities produced by loss of energy any differently from velocities caused by gain in energy in their computations. This discrepancy becomes apparent when we employ the above equations in atomic orbit calculations and the result serves as irrefutable proof that our frame of reference is moving with a velocity of c, a fact that cannot be ignored. For example, the circumference $2\pi r$ of the innermost orbit that an electron can occupy in an atom is equal to half the electron's particle wavelength in accordance with de Broglie's wave theory

$$\tfrac{1}{2}\lambda_e = \frac{Zq^2}{4\varepsilon_0 \nabla E}, \qquad (l) \quad (71)$$

and replacing $\frac{1}{2}\lambda$ with Equation (66) yields

$$\frac{\frac{1}{2}h\nabla v}{\nabla E} = \frac{Zq^2}{4\varepsilon_0 \nabla E}, \qquad (l) \quad (72)$$

where Z is the atomic number; ∇v the sum of the electron's and nucleus' orbital velocities around their common center of mass; ∇E the sum of their orbital energies; q the elementary charge; and ε_0 the permittivity constant. Solving for the electron's closest orbit in one-electron atoms (neutral hydrogen, singly ionized helium, doubly ionized lithium and so on) using the different velocity Equations (68), (69), (70) will result in

$$\nabla E_e = E_0\left[1-\sqrt{1-\left(\frac{Zq^2}{2\varepsilon_0 hc}\right)^2}\right]\times\frac{m_n}{(m_n+m_e)}, \quad \text{Collapsing Universe} \qquad (73)$$

$$E_e = \frac{m_e (Zq^2)^2}{h^2\varepsilon_0^2 8}\times\frac{m_n}{(m_n+m_e)}, \quad \text{Newton} \qquad (74)$$

$$E_e = E_0\left[\left(\frac{1}{\sqrt{1-(Zq^2/(2\varepsilon_0 hc))^2}}\right)-1\right]\times\frac{m_n}{(m_n+m_e)}. \quad \text{Einstein} \qquad (75)$$

The term $m_n/(m_n+m_e)$, where m_n and m_e are masses of the atomic nucleus and electron respectively, reduces the orbital energy to that of the electron only. The graphs in Fig. 12 show deviation in calculated values of orbital energies using the above equations as compared to measured values published in the *Handbook of Physics and Chemistry*. Both Einstein's theory of relativity and Newton's mechanics break down since they do not consider the motion of our frame of reference relative to the rest of the Universe and, thus, do not distinguish between energy gained or energy lost. Equation (73) which is based on the harmonic Universe shows no serious deviations. A small Compton red-shift of $\Delta\lambda \approx 5.3\times 10^{-14}\,\mathrm{m}$ was discovered in the published values and has been deducted. Much work has been done trying to apply Einstein's relativity theory in calculating atomic orbits, which has led to extremely complicated equations involving a multitude of correction factors such as the Dirac-Fock correction (Desclaux, (1981)); Self energy correction (Mohr (1981)); Uehling vacuum polarization correction (Uehling, (1935)); higher order vacuum polarization correction (Källen (1955)); and nuclear size correction.

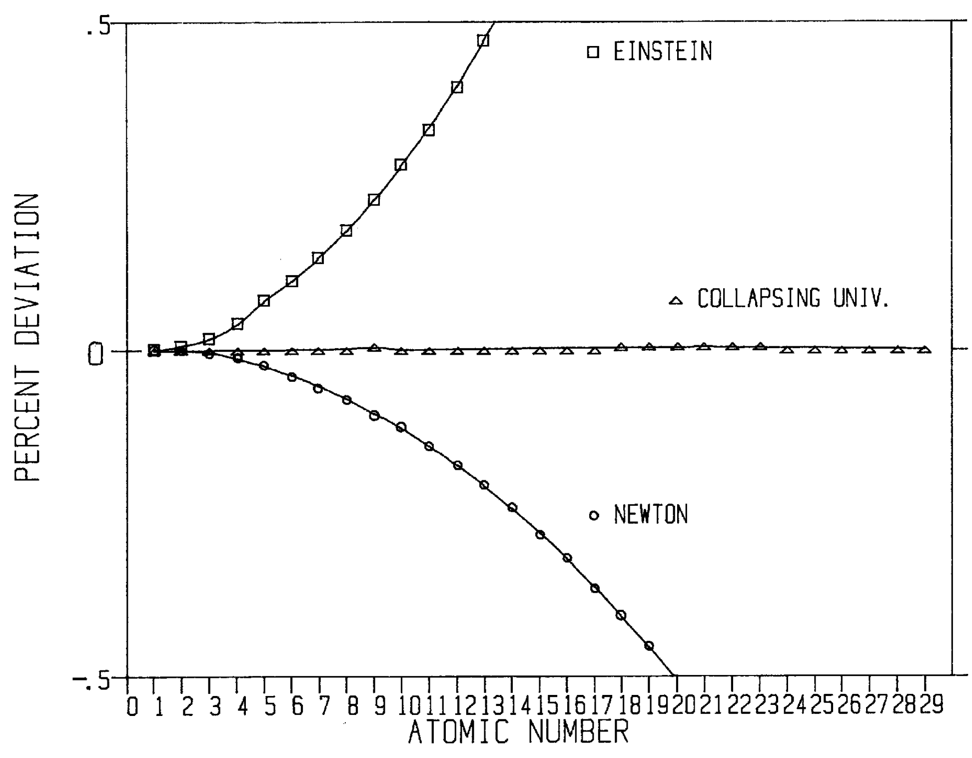

Fig. 12. Calculated ground state energies (highest ionization potential) for one-electron atoms as a function of atomic number Z compared to available measured data. Deviation of calculated values from measured values are shown in %. The three curves are based on Einstein's theory of relativity; Newton's law of motion; and the velocity equation postulated by the harmonic or collapsing Universe.

In the lower Z-range between 1 - 20, these corrections produce results very close to Equation (73) but deviate drastically at higher atomic numbers. To summarize, the results show that it is possible to calculate atomic orbits without any of the above correction factors if we take into consideration that our local frame of reference is traveling with the velocity of c and that the orbital velocities of electrons in atoms are the result of loss of rest mass energy. This, in the author's opinion, supports the collapsing Universe theory which is based on the laws of harmonic motion and which conform with Kepler's (1619) notion of a harmonic Universe presented in his much criticized work *The Harmonics of the Worlds.*

6.4 The photon

Photons are hard to envision. We know that a photon is a wave and needs a medium to propagate through, just as acoustic waves or ripples on the surface of a pond. We also know that a photon is not a continuous train of waves but only half a wavelength long, which gives it a pulse or particle appearance. The medium through which photons propagate is the universal gravitational tension ϕ_{univ} which permeates all cosmic space. As explained previously the universal gravitational tension is generated by all matter in the Universe and is determined by the expression $\phi_{univ} = GM_{univ} / R_{univ} = c^2$ (Mach's Principle).

One can perhaps describe a photon as a massless power pulse or wavelet which propagates through space at the speed of light. The energy E of a photon can be expressed in temperature such as $T = E / \frac{3}{2}k$, where $k = 1.380 \times 10^{-23}$ J/T is Boltzmann's constant and T the photon's temperature in degrees Kelvin. One can also determine the power per unit area delivered by a photon from Stephan's law of radiation $L / A = \sigma T^4$, where $\sigma = 5.67 \times 10^{-8}$ watts/m$^2T^4$ is Stephan-Boltzmann's constant and L the photon's power of radiation. From the above information one can obtain a reasonably good idea of the physical shape and size of a photon. For example, since the photons frequency and wave length are given by

$$\nu = \frac{E}{h} \quad \text{and} \quad \lambda = \frac{hc}{E}, \tag{76}$$

and the total power of a photon is

$$L = 2\nu E, \ \text{(watts)} \qquad (ml^2/t^3) \tag{77}$$

then the cross sectional area of the photon must equal

$$A = \frac{L}{\sigma T^4} \ \text{or} \ \frac{(\frac{3}{2}k)^4}{\sigma \frac{1}{2} hE^2} = (\tfrac{1}{2}\lambda)^2. \qquad (l^2) \tag{77b}$$

Since the length of the photon equals

$$l = \frac{Ec}{L} = \tfrac{1}{2}\lambda, \qquad (l) \tag{78}$$

we can roughly assume that a photon takes up a space in the shape of a cube with each side measuring $\frac{1}{2}\lambda$, see Fig. 13.

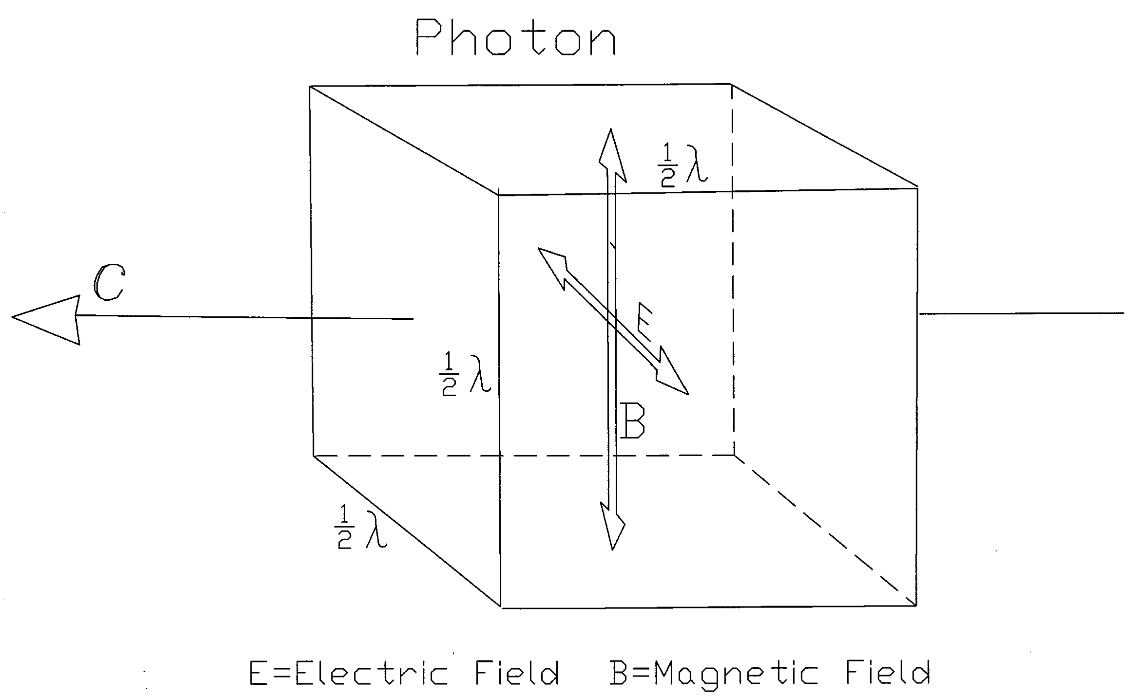

Fig. 13. The photon.

Below are some typical characteristics of a photon:

$$\tfrac{1}{2}\lambda = \frac{ch}{2E} = \frac{ch}{3kT} \text{ , half a wavelength} \qquad (l) \qquad (79)$$

$$U_r = \frac{E}{\left(\frac{1}{2}\lambda\right)^3} = \frac{\frac{3}{2}kT}{\left(\frac{1}{2}\lambda\right)^3} = \frac{81(kT)^4}{2c^3h^3}, \quad \text{energy/m}^3 \qquad \left(m/(t^2l)\right) \qquad (80)$$

$$L = \frac{2E^2}{h} = \frac{Ec}{\frac{1}{2}\lambda} = \frac{9(kT)^2}{2h}, \quad \text{power (watts)} \qquad (ml^2/t^3) \qquad (81)$$

$$L/A = \sigma T^4 = \frac{L}{\left(\frac{1}{2}\lambda\right)^2} = \frac{81(kT)^4}{2c^2h^3}. \quad \text{watts/m}^2 \qquad (m/t^3) \qquad (82)$$

6.5 The velocity of light

Although Maxwell successfully formulated his theory on electromagnetic fields and established that the velocity of electromagnetic waves equals *c*, the velocity of light, the question remained: what kind of universal medium or ether are electromagnetic waves propagating through? Great efforts have been spent in the search of a stationary ether, and numerous experiments have been performed trying to detect the Earth's movement through such a medium. Since no change in the velocity of electromagnetic waves at the Earth’s surface could be found in any direction, regardless of the Earth's motion through space, many abandoned the concept of an ether and claimed that electromagnetic waves ought to exist in empty space and therefore do not need a propagating medium. However, laws of physics require a propagating medium for any type of wave and the physical properties of such a medium must be

$$\phi = \frac{p}{\rho} \text{(tension)}, \qquad (l^2/t^2) \qquad (83)$$

where p is the pressure in newtons/square meter and ρ the mass density (inertia) per cubic meter. The pressure p of the medium is equivalent to energy density in joules per cubic meter. It is obvious to most of us that space is not empty, since it contains not only the gravitational tension of our Earth, Sun and planets, but the gravitational tension of the whole Universe. As mentioned before, the gravitational tension of the Universe at our vantage point x_0 in space, which equals $\phi_{univ} = GM_{univ}/R_{univ} = c^2$, by far exceeds the gravitational tension generated by our Earth and solar system (see Chapter 4, section 4.6). However, gravitational tension of individual gravitating bodies will add to the cosmic gravitational tension ϕ_{univ} and cause the propagation of electromagnetic waves to slow down in their immediate vicinity determined by

$$v = c\left(\frac{\phi_{univ}}{\phi_{univ} + \Delta\phi}\right)^2 \cong \frac{c}{1 + 2Gm/(rc^2)} \qquad (l/t) \qquad (84)$$

where $\Delta\phi = Gm/r$ is the gravitational tension of a body at the radius r and m is the mass of the body within r.

The velocity of light at the surface of the Sun for example, is about

$$v = c\left(\frac{\phi_{univ}}{\phi_{univ} + (Gm_{sun}/r_{sun})}\right)^2 = 2.997911 \times 10^8 \text{ m/s} \qquad (l/t) \qquad (85)$$

or 4×10^{-4} % slower than the free space value of c.

It is important to note that it is not the gravitational acceleration but the gravitational tension ϕ that determines the velocity of light. Gravitational acceleration is the gradient of the gravitational tension ϕ and its magnitude at a distance r of the gravitating body is

$$a = \phi/r = \frac{Gm}{r^2} \text{ Newton/kg} \qquad (l/t^2) \qquad (86)$$

It turns out that the Sun's gravitational acceleration ϕ_{sun} / r_{sun} in the vicinity of Earth is over a thousand times weaker than the Earth's own surface acceleration ϕ_{earth} / r_{earth}. However, the gravitational tension of the Sun ϕ_{Sun} at Earth, is fourteen times larger than the Earth's own gravitational tension ϕ_{earth} measured at the Earth's surface.

We find that light slows down near a gravitating body because of the increased gravitational tension. Gravitational tension also determines the rate of time (see Chapter 2, section 2.4) so that any increase in gravitational tension has the effect of slowing all physical processes, including clocks as well as the speed of light. The fractional slow-down of light, however, is twice that of the slow-down of clocks.

Gravity can bend or retard electromagnetic waves but Equations (84) shows that it is impossible to completely stop the propagation of an electromagnetic wave no matter how strong the gravitational field is. It is doubtful therefore, that gravitating masses exist from which light cannot escape such as "black holes", championed by many astronomers, unless they possess an infinite amount gravitational tension, which is unrealistic.