CHAPTER 5

RADIATION AND TEMPERATURE

Period (Hubble's time) and frequency of the Universe

Angular frequency (Hubble's parameter)

Force constant

Radiation

Temperature

The origin of Planck's constant *h*

In his book, *The Harmony of the Worlds,* Kepler presents his third law, known as the *harmonic law,* which describes how our planets are bound to the Sun in organized orbits where the square of the period of an orbit is directly proportional to the cube of the orbital radius. The discovery of the *harmonic law,* which was made before Newton's laws of motion, led Kepler to believe that practically everything in our Universe had to be governed by harmonics and he even wrote music scores representing the harmonic motions of the planets. Although Kepler has been criticized throughout time for his extraordinary beliefs in harmonics he was not far off the mark. Half the energy in the Universe, which is confined to radiation, is nothing else than spectra of frequencies and waves in perfect harmonic relationships. The physical laws that rule atoms, planets, galaxies and clusters of galaxies are harmonic laws of motion and there is nothing wrong in assuming that the whole Universe is a large harmonic oscillator.

5.1 Period (Hubble's time) and frequency of the Universe

The period or time it takes for the Universe to complete one cycle is simply

$$t_0 = \frac{2p\, x_0}{c} = 2.47118 \times 10^{20}\,\mathrm{s}\,. \qquad (t) \qquad (36a)$$

which equals a frequency of

$$n_0 = \frac{1}{t_0} = 4.046667 \times 10^{-21} \text{ Hz.} \qquad (t^{-1}) \qquad (36b)$$

Using the simple harmonic oscillator model in Fig. 4, Chapter 2 and assuming that our position is at an angular displacement of 45° will leave us with about 6×10^{19} s before reaching the central point $x = 0$, where all matter, now at x_0 , will have been dissipated into radiation. The rate at which matter radiates energy is therefore mc^2/t_0. In the following text t_0 is defined as Hubble's time and is the period of our oscillating Universe as seen from our reference point x_0.

5.2 Angular frequency (Hubble's parameter)

Since harmonic motions are cyclic in nature we can divide each cycle into a circular 360° rotation and state that one cycle per second is the same as an angular frequency or angular velocity of 360° per second. In practice, angular frequency or velocity is usually expressed in radians per second where $\text{rad/s} = 360^{\circ}/2p\,\text{s} = 57.3^{\circ}$ per second, see Fig. 9.

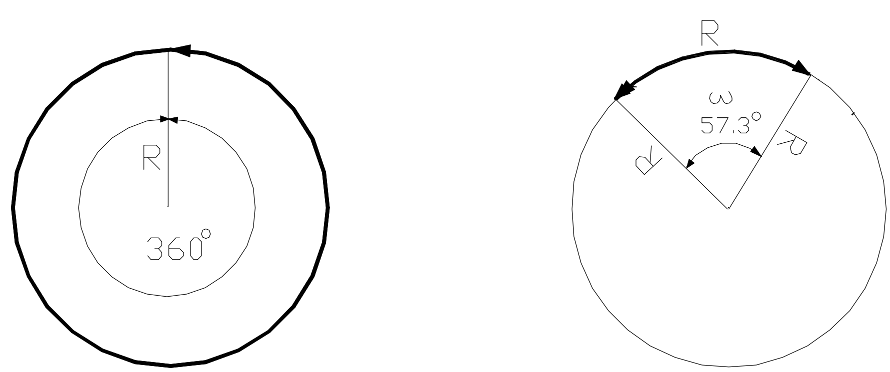

Fig. 9. The diagram illustrates a 360° per second rotation as compared to 1 radian or 57.3° per second rotation.

The angular frequency or angular velocity of our Universe, if one assumes a simple harmonic motion, is therefore,

$$w_0 = \sqrt{\frac{a_0}{x_0}} = 2.54258 \times 10^{-20}\,\text{rad s}^{-1}. \qquad (t^{-1}) \qquad (37)$$

The angular frequency or velocity is also given by

$$w_0 = \frac{c}{x_0} = 2.54258 \times 10^{-20}\,\text{rad s}^{-1}, \qquad (t^{-1}) \qquad (38)$$

assuming a circular or spiraling motion around its center. The only known observational results related to an oscillating Universe was rendered by Birch (1982), who studied polarization of distant radio sources which seem to indicate a large scale harmonic motion of the Universe at an angular frequency of the order of $w_0 \approx 10^{-20}\,\text{rad s}^{-1}$.

If the Universe follows a purely simple harmonic motion, where all matter is falling in straight lines toward the center of mass of the system, then the angular frequency will stay constant at any distance x from the center. If matter spirals in towards the center one can expect the angular frequency to change with x just as electrons and planetary orbits change angular frequency as a function of their orbital radii. We are at the present time unfortunately, only able to see a very small portion of our Universe which makes it difficult to decide what kind of harmonic motion we are part of. Although the feeling of the author is that we may be part of a large spiraling meta galaxy, we can still use equations of simple harmonic motions to probe the unknown properties of the Universe.

5.3 Force constant

When dealing with a simple harmonic motion it is often practical to use the mathematical term $k = ma/x$ where k is called the force constant.

In the oscillating Universe the force constant is

$$k = \frac{M_u a_0}{x_0} = 1.031040 \times 10^{16}\,\mathrm{kg\ s^{-2}} /(4p^2). \qquad (m/t^2) \qquad (39)$$

The force on matter in the Universe can also be written as $F = kx$ and is directed toward the equilibrium point $x = 0$. The force constant can also be expressed as $k = M_u w_0^2$, and has the dimensions of angular energy. In the large scale Universe, gravity is responsible for the force constant k.

5.4 Radiation

It is quite obvious that if matter loses all its potential energy to radiation over one period of oscillation, such as in a critically damped collapsing Universe, the rate of energy radiated by matter should be equal to the potential energy of matter E_0 divided by the period t_0 of the cosmic oscillation. As a result, the rate at which matter radiates energy, as seen from our reference point x_0 in space, must equal

$$L = \frac{E_0}{t_0} = n_0 E_0 \,(\mathrm{watts}), \qquad (ml^2/t^3) \qquad (40)$$

where L is the total luminosity or flux of radiation produced by matter in the Universe. From observations within the visible region of our Universe one can see that the ratio of mass to luminosity remains fairly constant over many orders of magnitude. Dividing the mass of the Sun by its flux of radiation produces about the same mass to luminosity ratio M/L as when we divide the mass of a galaxy with its flux of radiation or luminosity. The same ratio appears when we divide the total observable mass of the Universe with its total flux of radiation. Matter in the Universe will therefore, radiate energy as a result of the inward acceleration, just as atomic electrons radiate when falling closer to the nucleus. Also, from the theory of electromagnetism it has been established that matter radiates energy while accelerating and in a critically damped oscillator, such as the collapsing Universe, the energy radiated due to the cosmic acceleration a_0 is

$$L = \frac{m a_0 c}{2p} = E_0 n_0 \text{ (watts)}, \qquad (ml^2/t^3) \qquad (41)$$

which equals Equation (40). The luminosity of the whole Universe within our radius x_0 is therefore

$$L_u = \frac{M_u c^2}{t_0} = \frac{M_u a_0 c}{2p} = 5.80044 \times 10^{51} \text{ (watts)}. \ (ml^2/t^3) \qquad (42)$$

The diagram in Fig. 10 shows power radiated as a function of mass

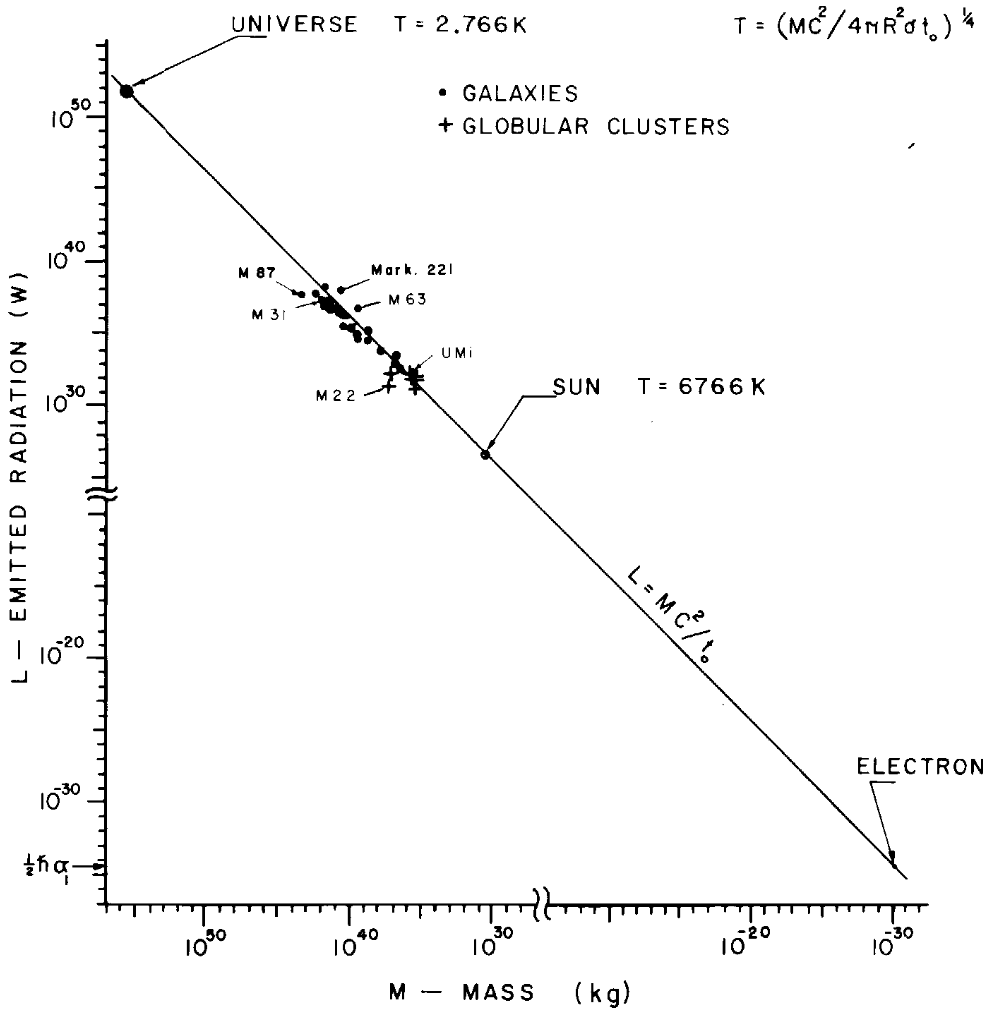

Fig. 10. Luminosity L as a function of mass M in the Universe.

for various matter in the Universe. Most of the data were obtained from Allen (1973) and Huchra (1977) and the solid line represents calculated values using Equations (41) and (42) ranging from the smallest quantum of matter, the electron, to the entire Universe. It is interesting to note that an electron, according to the diagram in Fig. 10, will radiate

$$L_e = \frac{m_e a_0 c}{2p} = E_0 n_0 = \tfrac{1}{2}\ddot{h} \qquad \text{(watts)}, \qquad (ml^2/t^3) \qquad (43)$$

where $\ddot{h}$ is Planck's constant expressed in power or $\ddot{h} = h/\mathrm{s}^2$, E_0 is the electron's rest mass energy and n_0 the fundamental frequency of the Universe. The equation implies that an electron, even at relative rest, has a zero-point radiation state and a specific temperature which will be discussed in the next section. Since matter is quantized and the electron being the smallest quanta of matter, it means that radiation has to be quantized as well. Equation (43) proves this fact because all symbols in the equation are constants including L_e. Equation (43) can also be written as

$$\frac{L_e}{a_1} = \tfrac{1}{2}\hbar, \qquad (ml^2/t) \qquad (44)$$

where $a_1 = 1\,\mathrm{rad/s}^2$, is unit angular acceleration, and $\hbar = h/(2p)$ is Planck's constant defined as power per unit angular acceleration (the origin of Planck's constant is discussed in section 5.6 at the end of this chapter). The fact that radiation is quantized and only appears in small power pulses rather than a continuous flow of energy allows us to write the radiation formula as follows:

$$L = \tfrac{1}{2}\ddot{h}\frac{M}{m_e} \text{ (watts)}. \qquad (ml^2/t^3) \qquad (45)$$

This means that the Sun must radiate $L_s = \tfrac{1}{2}\ddot{h}M_s/m_e = 7.23\times10^{26}$ watts of which $L = (L_s e) - p = 3.826\times10^{26}$ watts escapes unrestricted as pure radiation and where e is the emissivity of the Sun's surface and p the power of radiation used to propel the solar wind. The emissivity *e* is the ratio of a body's specific radiation leaving its surface as compared to the specific radiation produced inside the body and varies for different surface materials, but can never be greater than one. The emissivity *e* for the Sun is not well known. There is also a considerable amount of radiant power lost in the collision of solar photons with matter particles at and near the solar surface. This gives rise to the exterior solar wind which consists of high velocity particles ranging from electrons and ionized hydrogen to some of the heavier elements. The Sun's radiation equals a mass loss of about $L/c^2 = 4.25\times10^9$ kg/s which does not include the mass swept away by the solar wind. The amount of mass removed by the solar wind is comparable to the amount of solar mass lost to radiation.

If radiation is generated by the acceleration a_0 due to the collapse of our Universe, what part do nuclear transformations play in the heating of stars? Nuclear transformations are most probably the result of the extreme heat in stars rather than the cause of it, and judging from the Sun's neutrino flux, less than one-third of the solar energy is involved in nuclear reactions. Lanzerotti *et al.* (1981) point out that nuclear mechanisms in the Sun are not clearly related to the solar power output since they found no correlation between solar activity and solar neutrino flux. It should be mentioned that the existence of the elusive neutrino might not yet be an established fact. See Bagge, (1985).

Estimated M/L ratios for stars in our own galaxy, based on double stars, do not agree with the radiation mechanism presented here since they do not fall along the straight line in Fig. 10, but are believed to follow the relation M^3/L. This discrepancy can perhaps be explained by the fact that most observed double stars are in a high state of collapse or acceleration towards their own common centers of mass and therefore lose more energy to radiation than would be expected if they were only subject to the cosmic acceleration a_0. It must also be remembered that estimates of M/L ratios based on double stars are not at all conclusive, since they make up only a few percent of the total star population in our galaxy, and does not necessarily represent the true M/L ratio for all the rest of the stars in our galaxy.

5.5 Temperature

Temperature is interesting because it has no physical dimensions, yet its effect can be felt and measured. Temperature actually relates to the intensity of radiation or energy emitted per second per square meter, which is the same as power per unit surface area. For example, the Earth, which appears as a disk to the Sun with a radius of R_{Earth}, blocks πR^2_{Earth} of the Sun's radiation and, at our distance from the Sun, receives about $L/A = 1371$ watts per square meter, where A is unit surface area. Since the Earth's spherical surface area is $4\pi R^2_{Earth}$ or four times larger than the above πR^2_{Earth} area of received radiation the Earth will, as it rotates on its axis, in reality collect an average flux of four times less or 343 watts per square meter which, according to Stefan's law, corresponds to an average temperature of $T = (L/\sigma)^{\frac{1}{4}} = 279°$ Kelvin or $5.7°$ Celsius, where $\sigma = 5.670 \times 10^{-8}$ (Stefan-Boltzmann's constant). We know that the Earth is in a temperature equilibrium and radiates as much energy as it receives, namely 343 watts per square meter, which means that the global average temperature generated by the Sun's radiation is 5.7° Celsius in spite of any greenhouse effect.

From the total radiant power emitted by the Universe (Equation (42)) one can calculate its temperature from Stefan's law

$$T_u = \left(\frac{L_u}{4\pi x_0^2 \sigma}\right)^{\frac{1}{4}} = 2.766°\ \mathrm{K}\,, \qquad (none) \qquad (46)$$

or

$$T = \left(\frac{a_0{}^{2}}{4\pi G \quad t_0}\right)^{\frac{}{4}} = 2.766\ \ \mathrm{K}\,, \qquad (none \qquad (47)$$

Equations (46) and (47) suggests that the 2.766 K blackbody temperature is the product of scattered or thermolized radiation from discrete sources such as galaxies and stars *etc.* and from its dipole anisotropy we can determine the direction of our motion in the Universe, which appears to be towards 10.4hR.A. and -18 dec. on the celestial sphere (Smoot *et al* (1977)). The dipole anisotropy is caused by the movement of our Galaxy relative to the 2.766° K background radiation so that in the forward direction Doppler shifts make the background radiation appear slightly hotter than in the direction we come from. From these minute Doppler shifts we obtain an apparent drift velocity of about 500 km/s relative to a point from which a 2.766° K photon last scattered. The dipole anisotropy might be partly caused by a_0, the amount of acceleration of our galaxy towards the center of the Universe. One can also calculate the distance to the photons last point of scatter, which equals the photons mean-free path in inter-galactic space, from

$$\bar{l} = \frac{v^2}{2a_0} \approx 1.64 \times 10^{22}\,\mathrm{m}\,, \qquad (l) \qquad (48)$$

where $\bar{l}$ is the mean-free path and v is our velocity relative to the point from where the photon was last scattered.

One very interesting observation is that the black-body temperature of the Universe is equal to the black-body temperature of an electron using Equation (46) or

$$T_e = \left(\frac{L_u}{4p\, x_0^2 s}\right)^{\frac{1}{4}} = \left(\frac{m_e a_0 c}{8p^2 r_e^2 s}\right)^{\frac{1}{4}} = 2.766°\,\mathrm{K}\,. \qquad (none) \qquad (49)$$

Are we allowed to speculate? Could an electron be just another Universe?

There are several cosmological theories based on thermodynamics which involve the interaction between matter and radiation in the Universe. Most noteworthy is perhaps the oscillating cosmological model offered by P.T. Landsberg *et al.* (1992). The model describes a

Universe that goes through a numerous amount of expansions and contractions in which heat and matter exchange place.

5.6 The Origin of Planck's Constant

When Max Planck discovered one of nature's most mysterious constants *h,* quantum physics was born. The problem was, and still is, that Planck's constant has the physical dimensions of

$$h = E/n, \text{ (energy per unit frequency)} \qquad (ml^2/t) \qquad (50)$$

which is difficult to comprehend since it indicates that energy comes in the form of frequency which at the time could not be explained by classical physics. Max Planck himself nearly abandoned his theory after years of frustration trying to solve this mystery. Modern researchers have no problem with Planck's constant and do not question its origin since they simply believe it is a constant of nature and therefore needs no explanation. This attitude caused a split between classical physics, which demands a conceptual explanation to all physical phenomena, and modern quantum physics which is satisfied as long as the mathematical equations work out. It does not seem right, however, that there should be more than one kind of physics and a conceptual explanation of Planck's constant along the guidelines of classical physics would certainly bridge the gap between classical and modern thought. The harmonic Universe does in fact offer a reasonable answer to the question as why energy comes in steps of frequency. The harmonic motion of the Universe, provides the fundamental frequency from which all other frequencies are harmonic overtones. In other words: since the whole Universe oscillates at a fundamental frequency of n_0, then all matter contained within it will oscillate at the same frequency, or at any harmonic of n_0 just as overtones on a violin string are multiples of the string's own fundamental frequency, see Fig. 11. The fundamental frequency of matter in the Universe from Equation (36b) is $n_0 = 4.04665 \times 10^{-21}$ Hz.

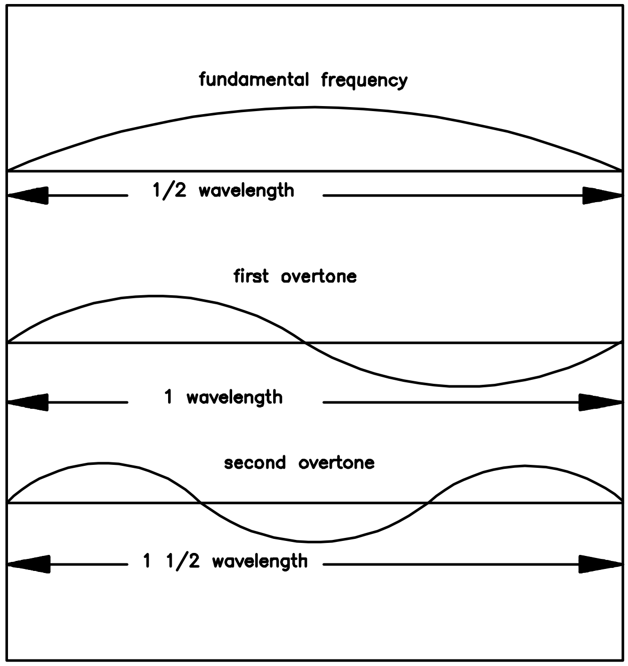

Fig. 11. A vibrating violin string showing the fundamental frequency and the first and second overtones

Only harmonics such as $2n_0, 3n_0, 4n_0$ *etc.* of the fundamental frequency can exist which means that an electron having a frequency of 1 Hz (which according to Planck's discovery corresponds to an energy of $E = 1Hz \times h = 6.6 \times 10^{-34}$ Joules) will oscillate at approximately the 247×10^{18} th harmonic of the fundamental frequency n_0.

To trace the origin of Planck's constant h we need to start from Equations (41) and (43) which show that matter is subject to a constant change in energy (power) while partaking in the fundamental frequency of the collapsing Universe. An electron will therefore, radiate a fixed amount of power generated by the fundamental frequency n_0 which is simply

$$L_e = E_0 n_0 = \tfrac{1}{2}\ddot{h} = 3.313 \times 10^{-34} \text{ w}, \qquad (ml^2/t^3) \qquad (51)$$

where E_0 is the electron's rest mass energy. Energy or power cannot change instantaneously but must change as a function of time. To change the frequency of an electron from its fundamental frequency n_0 to its first harmonic $2n_0$ will therefore involve power L_e and time Δt

$$\frac{L_e}{\Delta t} = \frac{\Delta E}{(\Delta t)^2} = E_0 2n_0^2 = 2.681334 \times 10^{-54}\,\mathrm{w\ s^{-1}}. \quad (ml^2/t^3) \tag{52}$$

Since a change in energy ΔE is directly proportional to a change in frequency (see Equation (50) we can write

$$\frac{\Delta E}{(\Delta t)^2} \propto \frac{\Delta n}{(\Delta t)^2}, \tag{53}$$

where $\Delta n = n_0$ represent the change in frequency required to step up to the next harmonic. Since the two terms above are proportional to each other then dividing one by the other equals a constant or

$$\frac{\Delta E/(\Delta t)^2}{\Delta n/(\Delta t)^2} = 6.626075 \times 10^{-34}\,\mathrm{w\ s^{-1}\ /Hz\ s^{-2}} = h, \qquad \left(ml^2/t\right) \tag{54}$$

where h is Planck's constant. The above reduces to

$$h = \frac{\Delta E/\Delta t}{\Delta n/\Delta t}\ \text{Power per angular acceleration}, \quad \left(ml^2/t\right) \tag{55}$$

which further reduces to

$$h = E/n\ \ \text{Energy per Hertz}. \qquad \left(ml^2/t\right) \tag{56}$$

To sum up, the reason why energy appears in steps of the fundamental frequency n_0 is explained by the fact that the whole Universe is oscillating and all matter in it will share its fundamental frequency, which causes energy of matter to change in steps unison with changes in the fundamental frequency n_0. When Max Planck discovered the relationship described by Equation (56), which is the reduced form of Equations (54) and (55), he could not possibly know its meaning since it can be seen that most information of its origin is lost in the reduction process. Max Planck was not able to determine the smallest quantum of energy because he had no idea what the lowest possible frequency (fundamental frequency) was. The smallest quantum of energy is $E_r = n_0 h = 2.6813 \times 10^{-54}$ J.

The smallest amount of energy in the Universe is the electron's gravitational self energy $E_g = G m_e^2 / r_e$ (see Chapter 4, section 4.6). If we divide E_g by E_r we obtain another one of natures mysterious ratios

$$a = \frac{E_g}{E_r} = 7.29735 \times 10^{-3} \quad \text{The finestructure constant.} \quad \text{(none)}$$