The Decrease of the Electromagnetic Frequency of Radiation from Stars

by A.C.Sturt

There are more things in heaven and Earth … than are dreamt of in your philosophy.

Hamlet, William Shakespeare.

Summary

There are two possible origins of the redshift of light from stars: either something causes it in the location of the star, or it happens during the travel of light from star to Earth. This analysis shows that it cannot occur at the star itself, because the frequencies of light generated by the star's activity must be the same as on Earth. The energy levels of atoms which give rise to these frequencies must also determine their chemistry, which is Universal. Anything else would make nonsense of the whole basis of science. The most likely solution is that it occurs during transit through space.

A mechanism is proposed by which a decrease of electromagnetic frequency occurs continuously as a particle of light travels from star to Earth. The relation between energy and electromagnetic frequency according to Planck suggests that such a decrease must occur exponentially with distance. Measurements are suggested by which this can be substantiated using standard observations on Earth which may already have been made. It is probably a question of re-interpretation.

A. Introduction

The present interpretation of redshift is unsatisfactory. The observed wavelength of light from most stars is longer than that emitted by the same species of atoms on Earth. From this it is inferred that the stars are moving away from us, and it is this movement that stretches out the distances between the peaks of light waves, which is their wavelength. Redshift is also separately observed to increase with the distances of stars from Earth which have been measured trigonometrically i.e. the further away the stars, the more the wavelengths are stretched. So adding two and two together, the further away the stars, the faster they are receding.

On the assumption that the Universe comprises the celestial bodies which we can see, the conclusion from this must be that the Universe is expanding. If the Universe is expanding, there must have been a time and a point at which the expansion began, and this has been labelled the Big Bang, the creation of the Universe from some sort of kernel. Implicit in this model is that at the first point there can have been no time because nothing was happening, and no space, because the distance between particles of matter was zero. Expansion of what, and why in such circumstances any expansion should have occurred at all, remain imponderables. These are in effect given.

If this model is valid, it must be a very strange Universe indeed. Planck showed that the energy of a particle of light is proportional to its frequency. But there is no

evidence that the electromagnetic frequency of light emitted by a source is dependent on the velocity of the source. The reason is that it is determined by atomic energy levels. If the electromagnetic frequency was dependent on velocity, then the chemistry of the atoms would also depend on velocity, since these are the same energy levels that determine chemical reactions. The conclusion of that would be that chemistry on Earth depends on its velocity, whatever that means, and chemistry at the Poles would be slightly different from chemistry at the Equator. The velocity of Earth in this calibration would of course be zero, and everything else is moving i.e. we would be right and the rest of the Universe would have to fall into line.

At this point the argument retreats into the assertion that light is really a wave not a particle. However, that does not answer the question of energy, and light certainly behaves like particles because it is particles of light, for example, which knock electrons out of place in CCDs and the chips in digital cameras. Light as particles is a fact. It just means that the phenomena are not fully understood. The argument simply evaporates if it can be shown how a particulate model of light can produce wave-like phenomena such as diffraction, as I have proposed (1).

What we have is a series of observations, that is measurements not interpretations or theories, which have to be reconciled in a clearer model. The only input is light; there is nothing else to go on. We may be observing more than one phenomenon at work. The following analysis proposes measurements which may help to settle some of these arguments.

B. Background

Redshift is detected by the absence of spectral lines in the continuous spectrum emitted by stars. These are not black lines, although this is how they appear, but no lines at all. They serve as markers which allow the shift of the entire spectrum to lower electromagnetic frequencies to be observed and measured. The particular patterns of ‘black’ lines are characteristic of the atomic species that are thought to be present in the atmosphere of the star, which absorb and filter out specific wavelengths of electromagnetic radiation, and so reveal their presence. It must be the case that the entire continuous spectrum is shifting, because all electromagnetic radiation travels at the same constant velocity *in vacuo*. This was confirmed long ago at the celestial level, when all the observed frequencies of light cut off simultaneously during an occulting phenomenon.

The idea of stretching of light waves originated with Doppler by analogy with sound, and was translated into mathematical form by Maxwell. Much later Hubble, in his Silliman Memorial Lectures and drawing on others’ previous measurements, said that redshift certainly increased with distance for stars i.e. in the Milky Way, but there was room for doubt whether the relationship was a straight line or a curve. He does not make the point, but analysis is also complicated by the choice of redshift as a ratio of the difference of ‘wavelength’ from the star to the wavelength produced by the same atomic species on Earth. Ratios can be difficult to unravel analytically, especially when two interacting variables are changing at the same time.

However, everyone seems to have settled for the straight line version, and attention moved swiftly to Hubble’s big discovery, the existence of galaxies other than our

own, which were more exciting and for which results were more reliable. But that ignored the fact that light radiating from a galaxy may not result from quite the same phenomenon as light radiating from an individual star. Since then vast numbers of measurements have been made on galaxies and embellished with the concepts of relativity, which introduces even more complexity, and I suggest more doubt, into the current model.

My new model proposes that electromagnetic frequency decreases exponentially as it travels through space at the constant speed of light *in vacuo* (2). A light particle progresses at the speed of light by electromagnetic induction of the medium of space, which I have called a RED or rotating electromagnetic dipole, rather like a tiny electromagnetic whirlpool. The electromagnetic frequency of rotation of the dipole decreases at every stage in proportion to its energy at that point, which makes the decrease of electromagnetic frequency exponential. Nothing is lost in transit because electromagnetic induction generates an associated particle of light with its complementary energy content, which compensates for the apparent decreasing energy of the primary RED. Thus the model is consistent with Planck's relationship.

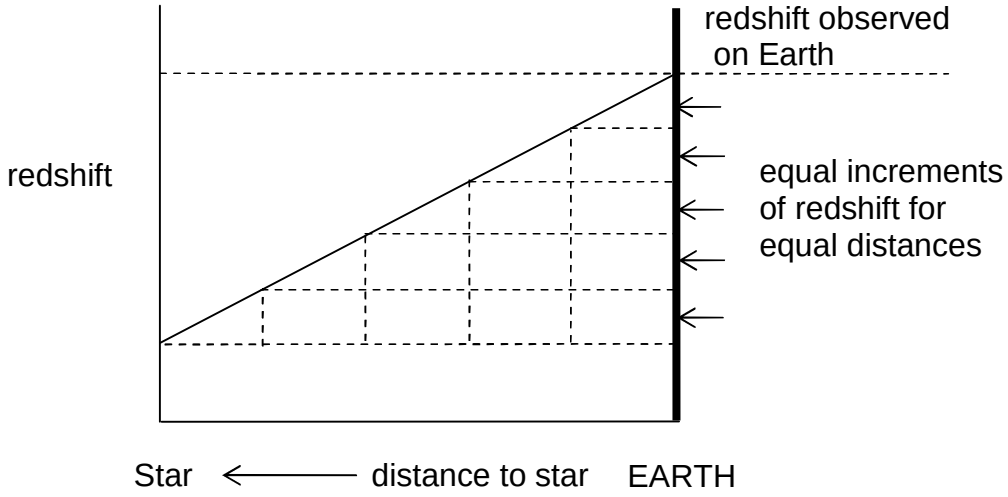
The present paper proposes a relatively simple way of establishing this exponential function, and evaluating the constant which specifies it. I suggested in a previous paper that a direct measurement of frequency change should be made by firing a ruby laser at the reflectors left on the Moon and detecting the reflection, which is already done to measure distance by elapsed time. The distance to the Moon and back is the only astronomical distance available to us which is unambiguously without radial motion relative to Earth, and so free from any conceivable relativistic effects. The present proposal expands the scope of measurement to all stars for which trigonometrical i.e. parallax distances can be measured in light years and electromagnetic frequencies in oscillations per second, without space-time adjustments.

C. The current straight line relationship

The straight line relationship used by Hubble is given by:

distance = constant x redshift

If a star has twice the redshift, it is twice the distance away. Alternatively, redshift observed from a point half way to the star would be half what is observed on Earth. Thus redshift observed on Earth is built up of equal increments proportional to the transit distance from Earth, as in the following diagram.



This relationship is purely empirical. No fundamental mechanism is advanced by which the emission of light from an atom relates to its distance from Earth. The assumption of the straight line relationship is that light generated by the star would be redshifted because the star has a radial velocity relative to Earth. But it must have the same wavelength as on Earth at the point of generation, if the chemistry is to be believed, and so the hypothesis is that it becomes extended by velocity through space before transmission to Earth. It is this velocity which is considered to give rise to the straight line and so the equal increments in the graph.

D. The exponential relationship

An alternative explanation is that the increase of wavelength occurs not at the star but during the transit of light from star to Earth through the medium of space. The analysis is simplified if we consider the phenomenon not in terms of proportional changes of wavelength but directly in terms of frequency.

As soon as a particle of light has been generated at the atomic level, it is in free space, whether it is then seen at the source or it travels through space to be seen at a distance. By definition it has to be free of the atomic structure which generated it to be detected. We know that the electromagnetic frequency at source is the same as on Earth, because chemistry is Universal. We know that the observed electromagnetic frequency is lower when it reaches Earth. We know of no event which could reduce the electromagnetic frequency instantaneously. The conclusion must be that a process occurs in transit which involves loss of energy continuously. Maximum loss of energy is likely to occur when the energy of the particle is at its greatest i.e. immediately on emission. It seems reasonable therefore to assume that energy loss is proportional to the energy of the particle at every stage, which means that the decrease of electromagnetic frequency occurs exponentially as the light travels through space (op. cit.).

The equation for such a process is:

$$f = f_0 e^{-\alpha x}$$

where f_0 is the fundamental frequency observed both on Earth and at the star, and α is the constant that determines the shape of the exponential. The value of the constant must be determined by observation and measurement.

Rearrangement of the function shows that:

$$-\alpha.x = \ln\frac{f}{f_0}$$

where x is the distance from the star to Earth. Restating it with x as distance from Earth to star, which is how we regard it:

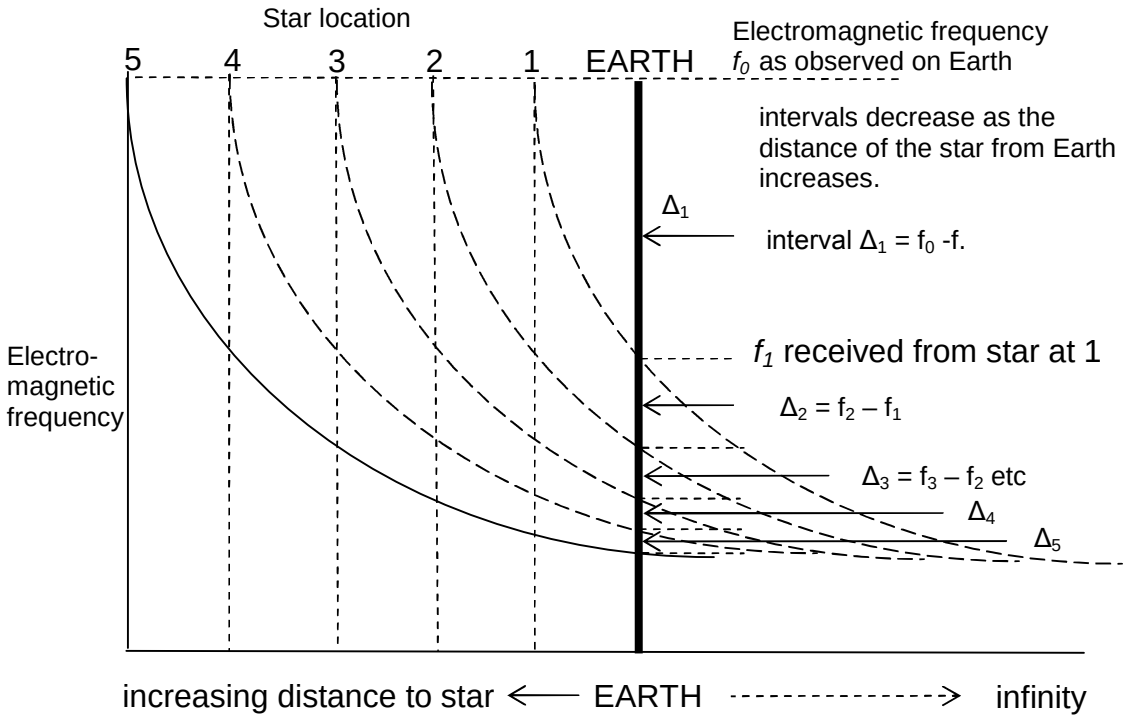
$$\alpha.x = \ln\frac{f}{f_0}$$

and the distance x from Earth to star is given by:

$$x = \frac{1}{\alpha}\ln\frac{f}{f_0}$$

From a knowledge of α and the measurement of f and f_0 the distance of the star can be calculated.

This can be shown more graphically in the following diagram:



By inspection the result of the exponential is to bring the furthest stars which we observe much closer to Earth than the current model predicts.

The loss of frequency is on the same curve, however far the star happens to be from Earth, because this is merely the observation platform on which we sit. Thus we can simply move the same curve left along the distance axis to see what happens from our viewpoint. This shows that the magnitudes of Δ, which are the intervals as defined of electromagnetic frequency *f* received on Earth, decrease as the distance of the star from Earth increases, even when this is linear i.e. moving from locations 1 to 5. This is because of the curve of the exponential function. In the absence of interception by a receptor or observer, the light continues on its way *ad infinitum*, though in an infinite Universe it will always meet a body and be absorbed or reflected.

What is true of a single star in different locations along the same direction, must also be true of a series of stars in each of those positions. Thus the same curve applies to a star at a distance 1 from Earth, and a star at distance 2 from Earth, and a star at distance 3 or 4 or 5 from Earth, because stars are in no way dependent on Earth; they will always behave as the laws of nature require, whether we are there or not. When their electromagnetic frequencies happen to be observed on Earth, the differences between them do not decrease at the same linear rate as their distances from Earth increase. This reason for this is the same as that given above: the curve of the exponential brings the values of all their observed frequencies closer together as they travel through space in the same direction, until they converge at infinity at the same value of zero, if they go that far.

Let Δ_1 be the difference between the electromagnetic frequency on Earth and the reduced electromagnetic frequency after transit through space from the star at location 1.

Let Δ_2 be the difference between the reduced electromagnetic frequency after transit through space from the star at location 1 and the reduced electromagnetic frequency after transit through space from the star at location 2. And so on.

Then because of the exponential nature of the curve:

$$\Delta_1 > \Delta_2 > \Delta_3 > \Delta_4 > \Delta_5$$

In fact the decrease of Δ is probably itself exponential in form i.e. the difference between the two such exponentials is itself an exponential function:

$$f_{n+1} - f_n = = f_0 \left[e^{-\alpha(d+1)} - e^{-\alpha d}\right]$$

All electromagnetic radiation emitted from this line of stars must follow the same exponential decay curve, because it is a function of the medium of space, which is common to them all. Thus the set of decay curves applies to all electromagnetic emissions from all stars in this direction. If it is assumed that the space surrounding Earth within the galaxy is isotropic, there is no reason to restrict the analysis to a particular direction. The corollary is that the radiation from all stars follows the same exponential function.

The importance of this methodology is that the exponential decay model can then be substantiated by direct observation on Earth from the decayed frequencies for all stars for which distances have been measured trigonometrically i.e. by parallax. If such stars are listed in order of distance together with their observed decayed frequencies, the decreases of Δ from one to the next can be calculated. Then if the successive values of the Δs lie on the same curve, this would be confirmation that the model of exponential decay is probably correct, and that redshift of electromagnetic radiation occurs during transit through space. The decay constant α which characterises the Universal curve can be calculated from the data for each of the stars, and combined for greater precision. It can then be used to calculate the distances of all stars, as far as space is isotropic.

The corollary of this would be that there exists a medium of space with electromagnetic properties. This would overturn the assumption of the past hundred years that the ‘ether’ does not exist, after Einstein declared that it was unnecessary.

E. The velocity of sources

It is most unlikely that a single measurement, namely redshift, could establish the values of two fundamental parameters of a source which is emitting electromagnetic radiation. If an imaginary receptor is located half way to a star and stationary relative to Earth, it will see half the redshift according to the straight line theory. But redshift is also claimed to describe the star’s velocity of recession. Does that mean that its

velocity of recession relative to Earth has also halved simply because of the measurement?

If measurements of the frequencies' differences (i.e. Δs) confirm the exponential function, this would show that decreases of electromagnetic frequency occur in transit, not at the location of the star. As a result we know nothing about a star other than the frequencies of light emitted at the star, and then only its surface, because we can identify the atomic species which must have emitted them and caused the pattern of black lines when the light reached Earth. This can tell us nothing about the velocity of the star; there is nothing in the particulate nature of light to stretch.

However, by the previous equation for distance electromagnetic frequency can be observed over time to give the velocity of recession *v* as follows:

$$v = \frac{dx}{dt} = \frac{1}{\alpha}\frac{d}{dt}\left[\ln\frac{f}{f_0}\right]$$

Acceleration of recession *a* would then be:

$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

or

$$a = \frac{1}{\alpha}\frac{d^2}{dt^2}\left[\ln\frac{f}{f_0}\right]$$

In other words we have to measure changes in frequencies to detect velocities and acceleration.

One other phenomenon is the observed splitting of lines which is caused by magnetic fields. The fundamental frequency must be the same as on Earth, unless we believe in magnetism-dependent chemistry. The conclusion is that particles of light are emitted by the atomic structure and then modified by the magnetic field of the star. The average of the split frequencies is then the same as the fundamental frequency observed on Earth.

F. Galaxies

All the above analysis refers to stars within our galaxy. Light from other galaxies is treated as the sum of all the light from the stars contained in the galaxy being observed, and so the same arguments apply. However, galaxies are by definition differentiated from other galaxies and from the space which separates them. Recent modelling shows that the various forms of galaxy can emerge simply as a result of the effects of gravity. This is the effect of the inverse-square law of gravitational attraction. But inverse-square laws are applied when phenomena are not entirely explicable (what exactly is gravity, and how does it exert its force at a distance?), and

so their effects have to be expressed by comparison i.e. twice as far, then a quarter of the force etc. In addition there is no distance at which the influence of the inverse-square law ends; you can always go twice as far.

The corollary is that there may be other phenomena at work which obey inverse-square laws. For instance, a plasma is a sort of gas in which the motions of electrons and positive ions are determined by their collective electromagnetic interactions. By analogy it could be postulated that the motions of bodies in a galaxy are governed by their collective electromagnetic interactions, of which gravitational forces are one manifestation. We would have to be outside our galaxy to be able to make measurements which would confirm this, but what we can affirm is that the space between galaxies would not be the same as the space within it. Or more precisely, the space between galaxies *per se* would be exactly the same within galaxies, but the presence of the bodies within a galaxy would distort its characteristics locally. More widely, the same could be said about the Sun's interactions with other stars inside the Milky Way, or the Earth's interaction with the rest of the Solar System from within its known magnetic bubble.

It is impossible to say whether any of this affects the conclusions about distances, because there is no way of measuring a distance that far away by trigonometry i.e. without recourse to the very properties of light which are being investigated. Other methods such as those involving luminosity have their own qualifications, especially if they rely on the Universality of the inverse-square law. The assumption that an inverse-square law is still in force at such vast distances needs to be challenged at the most fundamental level, which is the particle of light. It seems strange that light from galaxies should obey such a law, even though it may consist of just a few particles or photons when it reaches Earth.

The theory of cosmic expansion claims that redshift is evidence of cosmic expansion, stretching out space between, but not apparently within, galaxies. Cosmic expansion reveals itself in the form of redshift which therefore confirms cosmic expansion, surely a circular argument. The analysis of this paper suggests that measurements on Earth could shed some light on this.

The various mechanisms proposed above are not necessarily mutually exclusive. It is quite possible that some modification of electromagnetic emissions could take place near the body which is emitting them, and that other modifications might then occur during transit. There is no obvious reason why the mechanisms should interact.

G. The effect of rotation

The preceding argument is that the velocity of a body which emits radiation cannot affect its electromagnetic frequency. However, reflection is a different process. It may be possible that the velocity of a reflector affects the electromagnetic radiation which it reflects. For instance redshift may be measured to show the rotation of bodies such as the planet Jupiter, which can be confirmed by visual observation. Although this may seem at odds with the previous analysis, planets do not emit light; they reflect light. The conclusion would be that there must be a difference between emitted and reflected light.

The mechanism proposed here depends on the RED particle model of light. The RED particulate form is in fact a short spiral because the 'disc' of rotation is stretched out by the velocity of light; the first part of the spiral speeds away at the speed of light as the last part is still separating from the atomic structure which is generating it. Thus the RED has both a speed of rotation, which is its frequency in the number of rotations per second, and a length, which is the short length of the spiral in microns, which may be considered as its 'wavelength'. Neither of these is affected by the velocity of the atomic structure that emitted the RED, because the spiral is being spun off by the acceleration of electrons in the structure, which is not dependent on the velocity of the structure itself. As soon as the particle of light has separated from the structure, it travels at the speed of light, and no more interaction is possible.

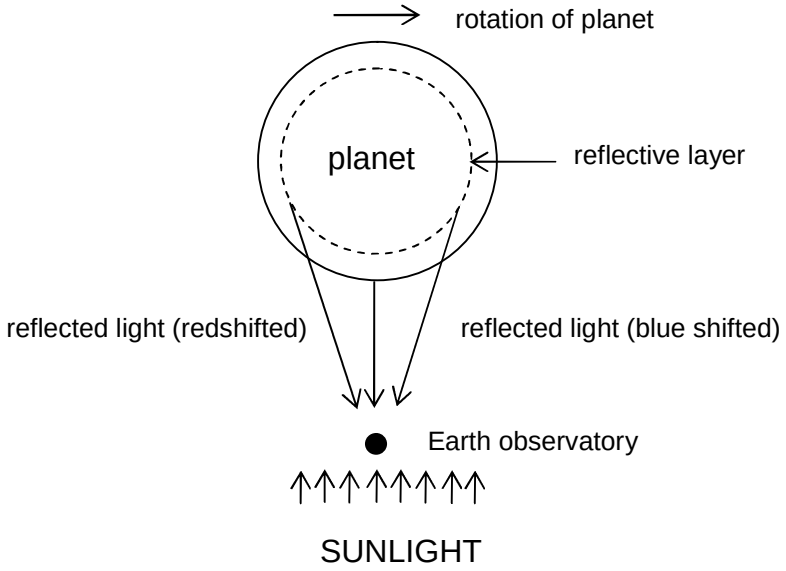
It follows that when a RED is reflected from a surface, the first part of the spiral hits the surface first and is reflected first, and the rest follows on. If the reflecting surface itself is moving, its velocity will affect the length of the spiral without changing its speed of rotation, which is the number of oscillations passing a given point per second. This is impossible by the wave theory of light, because by definition wavelength multiplied by frequency is a constant, the speed of light.

Thus if the reflecting surface is moving away from the RED along its line of travel, the interval between the first part of the RED to strike the surface and the last part will be increased i.e. 'wavelength' will be increased, which is redshift. However, if the reflecting surface is moving towards the RED as it strikes, the length of the RED will be compressed i.e. 'blue shifted'. Shifts are relative to the average of the two 'wavelengths' i.e. longer than the average or shorter. None of this depends on the source of the REDs, because the REDs are all in free space, so that their velocity is the speed of light irrespective of what the source is doing.

Such a mechanism has been described in the measurement of velocities on Earth by radar (3).

Thus the speed of rotation of the Moon on its axis or its velocity away from Earth, will cause very little redshift because it has none. Any change of wavelength of laser light sent from Earth and reflected back by the reflectors left on its surface must therefore occur in transit to the Moon and back, as proposed in a previous paper (4).

The redshift of sunlight reflected from Jupiter would be more complex. As stated above, light from the Sun is reflected out from the surface of the planet, which is why we can see it. However, it is suggested here that it also penetrates below the surface and diffuses. If there is a reflective surface below the surface, some would be directed back in the direction of Earth, and its 'wavelength' would reflect the speed of the reflective surface tangentially towards the direction of the Earth on the approaching side and tangentially away from the Earth on the departing side. The directions would not be quite tangential, because there is only a point contact by a tangent, and so nothing to observe. Thus the directions of measurement would cut some way into the body of the planet, and reach the reflective surface as in the Figure. The reflective surface may be a hard core or a phase with different reflective properties.



If these frequencies were blocked out by the atmosphere on the planet, they would also show as black lines.

A similar argument may be advanced for a redshift phenomenon of the Sun, in spite of the strictures of the preceding analysis. The Sun is close enough for us to identify all the wavelengths of its emissions. If it shows a pattern of black lines, it is because these frequencies are absorbed by atoms in the Sun's atmosphere. If the Sun is rotating, and if its surface is heterogeneous, it may be possible to identify motion by the mechanism described above.

This line of analysis raises questions about the fundamental mechanism of the sophisticated spectroscopic analysis which is used to measure wavelengths. Light is split into its components by diffraction gratings. The question is: does the grating sort by electromagnetic frequency of rotation or by 'wavelength'? For the current wave model this is not relevant because the two are always linked by the equation:

wavelength (microns) x frequency (number of waves per second) = constant

In this model, if wavelength changes so must also frequency, in order to keep their product constant.

However, the RED model proposed above suggests that 'wavelength' can be changed by reflection without alteration of the electromagnetic frequency of rotation. This would be a species of light particle new to science. 'Wavelength' changed, but energy would not have changed, because electromagnetic frequency did not change. The question then is what does a diffraction grating do? Does it separate components by electromagnetic frequency of rotation or by the length of the RED i.e. 'wavelength'?

A previous paper proposed a mechanism of diffraction which involved repulsion by coincidence of like charges (op.cit.). It seems that the most likely mechanism is

mutual repulsion by REDs of like frequency i.e. energy. It would need a detector which operated on a different principle to choose between the mechanisms.

The corollary would be that light particles which are classified by electromagnetic frequency may come in different species of 'wavelengths'. Thus the light reflected by different parts of a rotating sphere, the radial and the tangential, might contain assorted 'wavelengths'. This may not be as strange a proposal as it seems at first sight, because it has been observed that light which has been through various processes of polarisation cannot be reconstituted into its original form.

The theory of reflection would be hard put to it to justify the movement of stars and galaxies in the mechanism suggested above, but it may not be impossible. It would mean that we do not see starlight, or perhaps just starlight, but also the reflections of light which the galaxies shine on themselves. It is difficult to identify the separate rotational redshifts of individual stars or bodies, because these are point emissions. Otherwise the conclusion must be that there is still no satisfactory mechanism for the appearance of motion in the spectra of stars or galaxies, which the current model requires.

H. Conclusions

The linear relationship of redshift to distance is essentially an anthropocentric model. It appears to have no basis in the fundamental mechanism by which electromagnetic radiation is generated at the atomic level. If it had started from an astrocentric position, the analysis might have taken a different turn.

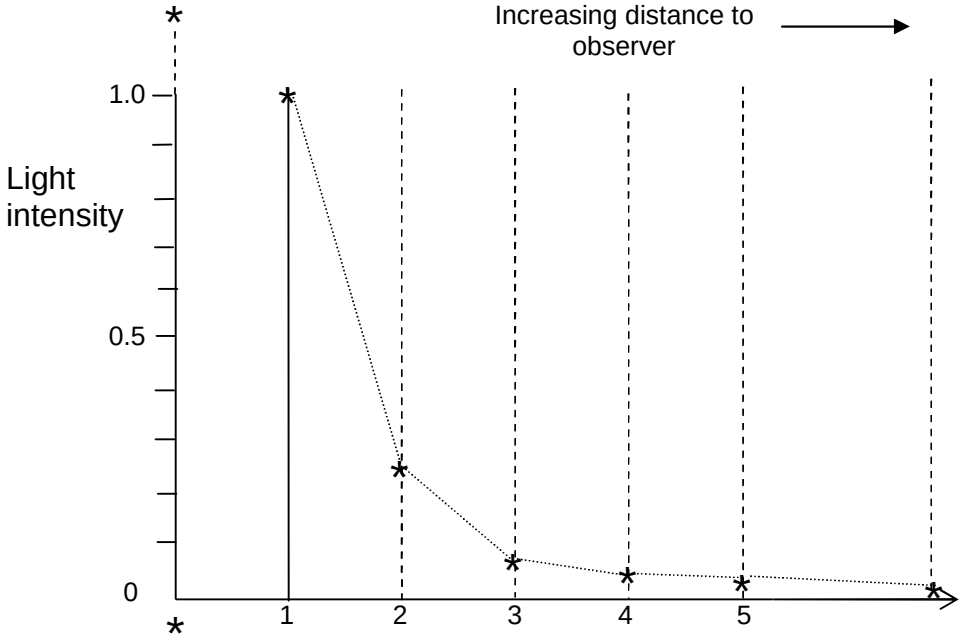
The potted historical sequence appears to be as follows. Newton uncovered the mysteries of the spectra. He believed that light was composed of particles, but he was unable to reconcile this with diffraction, mainly because he was applying mechanics and its forces to a phenomenon for which it was inappropriate. The result was that the Huygens model of light as waves prevailed. Attention turned to the spectra of astronomical bodies, and small displacements were found towards the red end, red-shifts, and towards the blue, blue-shifts. When Doppler discovered his effect in relation to sound, he proposed by analogy that these displacements of the wavelengths of light were caused by radial velocities of stars towards or away from the Earth, towards the blue or red respectively.

However, he did not turn his theory into mathematical form, and this was left to Maxwell, who also showed that the waves of light were electromagnetic. Einstein's proof that light could certainly behave like particles was a contrary indicator, but it became subsumed in the term wave/particle duality i.e. light behaved like waves in some situations and particles in others. This simply glossed over the fact that the fundamental nature of light was not understood. When Hubble discovered that there were galaxies outside our own, the rush was to apply this theory of redshift to these. Suddenly the entire Universe was rushing away from Earth. The only conclusion had to be that the Universe must be expanding.

However, the key observation which had been made was that the fainter the star, the greater was the observed displacement of the spectrum. This was noted by Hubble

in his Spilliman lectures (5). Nevertheless the focus remained on ‘waves’ and ‘wavelengths’. Somewhere along the way the actual displacements of spectra, or red-shifts, became proportional displacements, which gives us the definition of redshift used in analysis today. The use of this ratio of wavelengths combined with its anthropocentric focus combined to obscure the underlying relationship of displacement of spectra and the meaning of faintness.

This becomes clearer if we draw a diagram similar to those above, using the inverse-square law, starting at the star.



The inverse-square law cannot apply at the star itself, because the calculated value would be infinite. This would be nonsense because there is no such thing as infinite brightness, and because it would reduce all stars to the same value, which they are clearly not. Some stars are brighter than others, wherever you stand. (This is an exact parallel with the inverse-square law of gravitational attraction, which predicts that all bodies have the same i.e. infinite attraction at their surfaces. We would all have an infinite weight on Earth, which is equally absurd.) Thus we have to move away one unit of distance to make the measurement: a metre, an astronomical unit, a light year etc. What the law predicts then is that twice as far away, the brightness is reduced to a quarter, three times as far away, to a ninth of the brightness and so on. The more units distant the observer, say on Earth, the fainter the star.

This curve bears a striking resemblance to the exponential curve shown above for the decline of frequency with distance. No wonder that displacement of frequency correlates with faintness, in fact almost linearly by inspection. However, if faintness is used to determine distance, it is vitally important to measure the unit distance from star to point 1, which is the closest point of observation, as accurately as possible, by indisputable means, by trigonometry or by use of α and the exponential distance

equation if this is proved. Errors in the unit distance multiply as the distance increases.

By contrast the exponential model is rooted in the particulate nature of light which is undoubtedly correct in many circumstances, and probably correct in all applications if the model of rotating electromagnetic dipoles is accepted. It is an absolute measurement, and it starts at the star. But it does require reinstatement of the medium of space, rather like the 'ether' which has been rejected by physics for the past century. Such a reinstatement would not have surprised Newton or Faraday one little bit.

Which of these alternative models is valid can be decided by measurements which are already routinely made on Earth. This requires us to return to the raw data and use unadorned frequencies expressed as oscillations per second rather than ratios of wavelengths, especially when these are further embellished with relativity. If confirmed, these data plus trigonometrically measured distances would allow the calculation of the constant α, and so the exponential expression for any emitter of electromagnetic radiation anywhere in the same isotropic space.

The implications of the exponential model for cosmology would be profound. It could be that the hypothetical expansion of the Universe is at least to some extent the result of choosing the linear model rather than the exponential; the concealed curvature reappears as the expansion. The exponential model brings every star and probably every galaxy which we observe much closer than we thought. The limit of present observation may not be much further in light years than the age of the Earth, that is firmly established by a quite different phenomenon, radioactive decay, for which the tools are very sophisticated scintillation counters and timekeepers i.e. measurements not hypotheses.

If the new model shows that our solar system and Earth were forming around the same time as the furthest observed light was shining, it would point to a steady state Universe. We know that it is ceaselessly changing, because of what we can observe from Earth, and so there must be a Universal feedback system to maintain the steady state overall. This suggests a Universe that is stochastically regenerated part by part through aggregation of matter under gravitational influence and distribution of materials and energy through explosion (6).

The corollary of this would be a Universe which is infinite in time and space.

What seems clear is that the phenomenon of light is more complicated than believed at present. Simplistic Doppler solutions may not be valid, even when they appear to give the right result. Reflection of particles of electromagnetic radiation and deflection of such particles by each other and at boundaries may even produce different types of light which are polarised and in which frequency and 'wavelength' vary separately, though of course within limits.

The effects of galaxies are not clear. They have a certain coherence of their own; it is between galaxies, not within galaxies, that cosmic expansion is thought to occur. If this is real, and the expansion model is valid, it suggests a fundamental change in the nature of space inside and outside galaxies, caused by the bodies of which they are

comprised. Any effect of this on light transmission is yet another imponderable which could only be settled by measurement.

All stars emit in all directions. Space is full of electromagnetic radiation, progressively decreasing in electromagnetic frequency. We see only that which is directed at us, because it is one-dimensional. One final thought, the steady decay of all electromagnetic radiation to low frequencies, as shown by the long tails in the figure which illustrates exponential decline, would be consistent with cosmic background radiation.

A.C.Sturt

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