18

The passive photon

18.1 The early researchers

The nature of light has always held a certain fascination and long before the work of Snell and Descartes in the early sixteen hundreds, it must have been recognised that there was more to it than met the eye. For example, small pieces of clear glass and many precious stones could produce some quite spectacular displays of colour when they caught the light in a particular way. Although it is true that Willebrord Snell, Professor of Mathematics at Leyden University discovered the relationship between the angle of incidence and refraction of light in 1621, it wasn't until the work of Sir Isaac Newton and Christiaan Huyghens that a real understanding of the nature of light began to take shape. Newton's work on the subject arose out of the need for finding a way of correcting the very annoying coloration or *chromatic aberration* that was inherent in the optics of the early telescopes of the day.

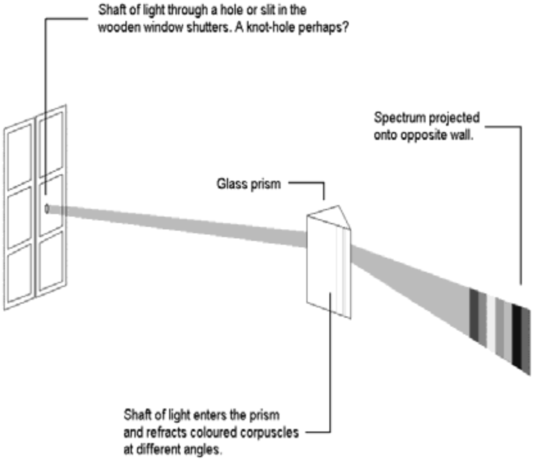

Figure 18.1.01 *Newton's original experiment with the prism at Cambridge in 1666. It became the basis of his 'Corpuscular Theory'.*

His experiments, carried out at Cambridge so the story goes, included the making of a small hole in one of his window shutters (or the use of an existing crack or knot-hole), which allowed a narrow beam of sunlight to be projected onto the opposite wall of his (presumably now darkened) room. Newton then placed a triangular glass prism into the path of this beam of light and found that it produced an elongated patch on the wall that was quite unlike the original sunlight (see *Figure 18.1.01* in the previous column); although Newton was probably not that surprised, as he must have already experimented with the properties of the prism beforehand. Instead of the familiar 'white light', this elongated patch consisted of bands which Newton christened 'spectrum' from the Latin meaning 'ghost'. This separation of white light into its component colours (or dispersion), led Newton to believe that when white light falls onto a prism, each colour is refracted at a *different* angle, with the result that the colours are spread out to form the now familiar spectrum.

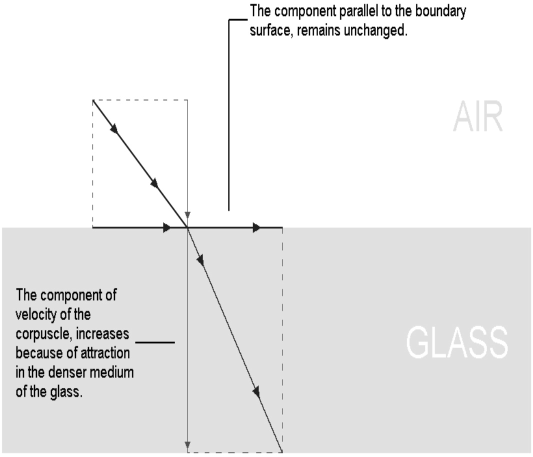

Figure 18.1.02 *The mechanism of bending when light enters a denser medium (such as from air into a glass prism), according to Newton's Corpuscular Theory.*

Taking the evidence of this discovery into account and what was already known about light; such as the fact that it always appears to travel in straight lines; always casts distinct, sharp shadows and that a mirror reflects it (i.e. it bounces off), it probably seemed quite logical to Newton to assume that light was a collection of different coloured tiny particles or *corpuscles*, that the prism refracted at different angles. This in turn, produced the observed spectrum on the opposite wall of his study. Mathematically, he was able to explain this new phenomenon with the use of vectors, which incidentally, required light to travel *faster* when it entered a denser medium such as the glass prism. In later experiments, he was able to re-combine the component corpuscles back into white light with the inclusion of a simple lens, thus reinforcing his theory. He also painted the colours of the spectrum onto a disc which, when rotated at high speed, gave the appearance of white light; (although he was actually unaware of the phenomenon of 'persistence of vision', where the brain tends to blend the rapidly rotating colours, producing the sensation of a white image).

The Danish astronomer Christiaan Huyghens, expanding upon the work of Descartes, was of the opinion that light consisted of waves that were carried in a medium he called the 'ether'. This he argued, permeated all space, the voids between the atoms and was ever present, even in a vacuum. Huyghens too, could quite adequately explain the presence of the spectrum - again by refraction, although stating that light *slows down* in the dense medium of the glass prism. This was the opposite to Newton's view that his corpuscles actually speeded up. There were also some striking similarities in the way water waves (ripples) and light behaved, such as the way that two beams of light, like two opposing ripples in water, will cross without affecting one another. Particles, or Newton's corpuscles, would surely collide in some cases, creating a disturbance which clearly, they did not seem to do. On the other hand, Newton's advocates referred to the sharpness of cast shadows. Wave motions tend to wrap around an object that they encounter which if this was the case with light, would surely cause a fuzzy or blurred outline, which was not of course, what appeared to happen.

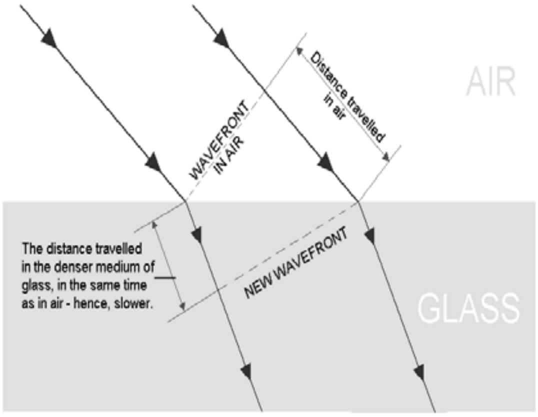

Figure 18.1.03 *Huyghens' wave theory of light.*

Although research continued after Newton and Huyghens (Olaus Roemer and James Bradley to name but two) and advances were made in the measurement of the speed of light and with optics in general, the corpuscle verses wave theory debate continued for some time. Probably because of Newton's already great standing in the scientific community, his 'Corpuscular Theory' seemed to win the day. It wasn't until Thomas Young's experiment in 1801, that opinion began to swing in Huyghens' favour.

Thomas Young, an English physician and physicist, figured that by projecting a narrow beam of light through two closely spaced holes onto a screen beyond, it would be possible to see Newton's corpuscles *at work* as it were. The resulting image should consist of two overlapping circles of light from the two holes. They should also produce an area in the centre of the image that was brighter, where the circles overlapped. However, this wasn't the case and instead of the overlapping images that would tend to prove Newton's theory, Young observed a series of bands of light, separated from each other by alternating dark bands (see *Figure 18.1.04* on the next page). It seemed to him that these dark intervals between the brighter bands, were where the light overlapped and where this occurred, this overlap seemed to add up to *darkness*. Newton's corpuscle theory couldn't explain this new phenomenon, whereas Huyghens’ wave theory could. In the bright areas, the bands tended to reinforce each other and seemed to be 'in-phase', whereas they cancelled each other out in the dark intervals and therefore appeared 'out-of-phase'. Huyghens' theory seemed to provide the answer.

Young later repeated his experiment, substituting the pin holes with two narrow parallel slits and obtained similar results. As well as proving that Huyghens' wave theory was correct, Young's work also provided a means of measuring the wavelength of light, which was found to be very small indeed.

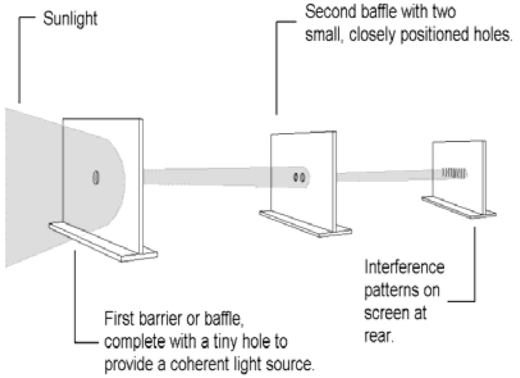

Figure 18.1.04 *Young's experiment of 1801 finally swung it for Huyghens, as the interference pattern projected on the screen at the rear didn't fit Newton's theory.*

This seemed to account for Newton's observation that light travelled in straight lines and produces crisp, sharp shadows - as the wavelength was in fact, much, much smaller than the objects it encountered. In later years, especially after the advent of the microscope, it was realised that light waves *do* in fact bend around objects if they are small enough, as is the case with some bacteria. By applying quite straight-forward geometry to Young's experiment, the wavelength of light was determined and more importantly, found to have a direct relationship to colour. Differing lengths of light waves corresponded to the different colours of the spectrum; longer towards the red and shorter towards the violet. The true nature of light was at last becoming clearer.

Experimentation continued during the following years and included the important works of Fresnel, Fizzeau, Fraunhofer, Babinet, Angstrom, Faucault and others - all of whom contributed to our understanding of light. This included better methods and therefore better results for obtaining accurate measurements of the wavelength and the speed of light. At around the same time (1820's onwards), Michael Faraday was undertaking his experiments into the nature of electricity and magnetism, which were to help establish light as something more than its visible evidence suggested.

18.2 Light, electricity & magnetism

Continuing on the work started by Faraday, James Clerk Maxwell in 1864, was able to show mathematically, that light was not simply a singular phenomenon - but a small part of a greater 'electro-magnetic' spectrum, most of which, was invisible to us. This seemed to explain other observations, such as Hershel's in 1800, who had observed heat beyond the red end of the spectrum - and Ritter's later experiments concerning the behaviour of silver nitrate in the other direction, beyond the violet. Continuing research widened the electro-magnetic spectrum still further as radio waves, x-rays, and gamma rays were added to the list. It was soon realised that all of this radiation travelled at the same speed in a vacuum - the speed of light - and differed *only* in its wavelength (distance between successive crests) and frequency (waves generated per second).

As research continued and our understanding of the electro-magnetic spectrum seemed to be becoming more or less complete, it suddenly became somewhat apparent that something still wasn't quite right. The accepted theories did not seem to be able to explain what was known as *black-body radiation*, or the way that an ideal body would be expected to emit (or absorb) electro-magnetic radiation, through all the various wavelength bands. Instead of behaving as the conventional theories dictated, it was found that the radiation emitted by a body depends only on its temperature and that it did not in fact, radiate equally through all the wavelengths. The short wavelengths appeared to carry little of the total emitted energy, as did the longer wavelengths. This energy seemed to peak somewhere between the two, depending on temperature (see *Figure 18.2.01* below). Why did it not radiate across the entire spectrum of electro-magnetic radiation as had been expected?

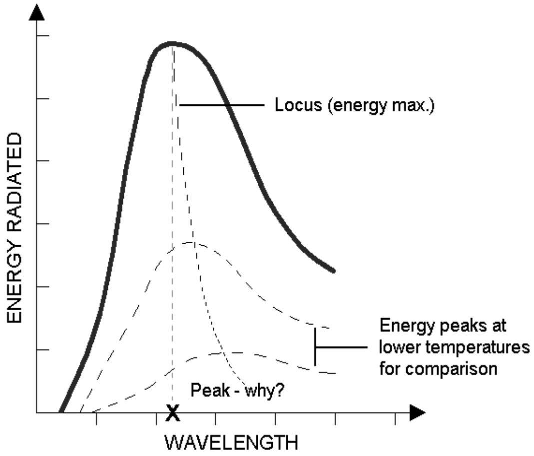

Figure 18.2.01 *Typical energy distribution/wavelength graph, for a body at a fixed temperature. Why did it peak at a particular wavelength, instead of radiating across the full spectrum?*

In 1900, the German physicist Max Carl Ernst Ludwig Planck arrived at his revolutionary theory that seemed to solve the black body problem. He proposed that when a body radiates energy, it was not as a continual emission at *ALL* wavelengths, but comprised small packets of energy that he christened a *quantum* of energy, after the Latin for 'how much'. He envisaged that the amount of energy in the quantum depended on the wavelength of the radiation emitted. In other words, the shorter the wavelength (higher frequency), the greater or larger the energy packet, or quanta.

For medium wavelengths, the quantum was of medium energy and the longer wavelengths produced the least energy. Therefore, Planck was saying that the energy content of a quantum, was inversely proportional to the wavelength of the radiation and was also directly related to the frequency. He expressed this relationship by his now famous equation:

$$\varepsilon = hv$$

where *'ε'* stands for the quantum energy, *'v'* (or nu) for the frequency and *'h'* for the 'Planck Constant'. The equation gave the proportional relationship between quantum energy and frequency and allowed for the 'peak' in emitted radiation. Although too revolutionary to be accepted at once, with continuing work by many of his contemporaries; his theory finally fell into place, when evidence in favour of his quanta were finally established.

With all the serious research that has been undertaken since the fifteenth century, light *still* remains an enigmatic puzzle and *still* retains its apparent paradox of *wave-particle duality*. There became two stables of thought - two models; *the electro-magnetic wave model of light* and a particle model; *the photon model of light*; both of which could be used to explain this phenomenon and a *phenomenon* is exactly what light appeared to be. These days, we seem to take it for granted because it has always been there, part of our every day lives. Apart from the fact that we would be dead without it, we would surely miss it if it suddenly wasn't there. How can such a familiar part of nature exhibit such strange behaviour - with this duality that even now in the twenty-first century, defies definition as either a waveform or a particle? This is more like the tip of the proverbial iceberg and there is certainly more to it than meets the eye.

The *electro-magnetic wave model* allowed physicists to describe light in the context of the electro-magnetic spectrum, of which it is just a narrow visible window. This window, which defines the range of wavelengths we can detect with our eyes, is no accident and we have been given this ability by evolution because of the environment in which we live. Not surprisingly, green lies more or less in the middle of this window and it is not difficult to conclude that it is an important colour for the primates (of which we are a part), as the great majority are vegetarians. Other animals have evolved in different ways of course, like the snake with its infra-red sensors and some moths that can apparently see in the ultra-violet. Within our modern twenty-first century technology, we make good use of almost the entire range of electro-magnetic radiation, from radio waves to X-rays and our modern world has come to strongly depend on this newly evolved ability. We should understand therefore, that the tiny window through which we visually experience the world and the universe around us, is really rather insignificant when one considers the overall scale of the electro-magnetic spectrum. In this context, light really is the tip of a very large iceberg.

18.3 Light as a dim-wave

Chapter Eight touched upon this paradox that has always been associated with the nature of light, for it can still be described as both a waveform and a particle (or ‘packet’ that we usually refer to as the *photon*). Within *this* model, this will inevitably be allied to the dimensional boundary surface wave and its propagation and the wave characteristic of light can therefore be defined here as a dim-wave. That the photon exists as well, is now seldom disputed and is of course central to quantum theory but, *WHY* this duality in the first place? This question is often treated as 'matter of fact' and few of us seem to pause these days to actually think about just how profound this really is. Why for example, does nature need this duality, when either one of its manifestations would quite amply suffice? As with many a phenomenon in nature, there occurs both a primary and a secondary effect and light too, may possess such qualities. I shall try to elucidate.

Chapter Six has attempted to illustrate the concept of dimensional boundary surface waves and it was postulated that these, as their name implies, should be regarded as surface waves. All surface waves propagate at the boundary between two distinctly different media and are by their very nature a transverse waveform. Their propagation at the boundary would in this context, be the primary effect and there is also little doubt, that any waveform also comprises energy. It was further postulated that dimensional boundary surface wave energy will attenuate just like any other and - as energy can be neither created nor destroyed, this attenuation must take the form of a condensation from higher to lower dimensional energy. As illustrated with the blackboard analogy in Chapter Six (*Figure 6.4.01* on page 43), this attenuation will deposit minute amounts of 'condensed out' dim-wave energy close to the plain of propagation and, as this energy is four-dimensional in its least energetic form, this deposition will be a 'downward' dimensional condensation that will occur on our side of the 3D/4D boundary. As one can imagine, this will produce infinitesimal amounts of three-dimensional material into four-dimensional space, just as a stick of chalk dragged across the blackboard will leave a chalk-line behind it. This will produce light's *secondary* effect and together with its naturally propagating (expansional) wave motion, we are presented with what results in the characteristics of duality.

As the wave motion passes, these tiny condensate particles will lose the momentum provided by the wave's energy and will eventually become *passive*, in that they will no longer contain an excess over and above that of their own energy threshold. These animals can perhaps best be visualised as even tinier versions of the acicularly described independent dimensional boundary chords and may also vibrate or resonate at a ground state energy level until acted upon by outside influences. The actual size of these ***passive photons*** as they will be called, is difficult to determine at this stage, but may lie any where between the quoted size of the *IDBCs* and that of the Planck scale. In their natural, condensed-out state, these *passive photons* will not radiate energy of any kind and are therefore to all intents and purposes, invisible to us (although their natural resonance may be so small as to elude detection at this stage). However, should they become exited by some external influence, they will acquire energy and will therefore, no longer be passive. They will emit radiation over and above that of their energy threshold which in all cases, will be electro-magnetic radiation; in the form of their own dimensional boundary surface wave emission. What was originally a condensed out ‘remnant’ dim-wave particulate, will have become the photon that we tend to recognise today. This secondary effect (or indeed process), will have every thing to do with the interchangeability of matter and energy; a concept central to modern-day physics.

It was also postulated in Chapter Six that dim-wave propagation at the 3D/4D boundary would influence three dimensional matter on this side of the boundary, although this would depend on the wave energy involved. It was also speculated that such interference would manifest itself as a form of *particle orbital motion* similar to that found within the action of water waves and Rayleigh waves within the earth - both of which are of course surface waves themselves. This was illustrated in Chapter Six and is repeated here as *Figure 18.3.01* below.

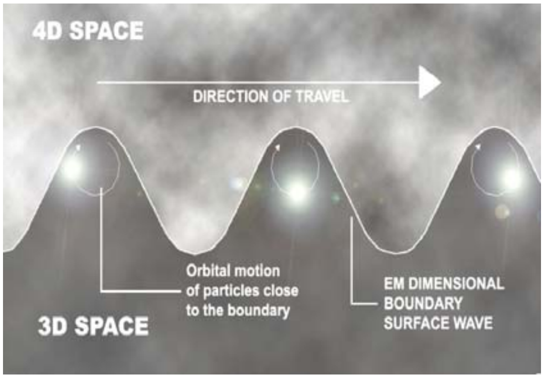

Figure 18.3.01 *As a dim-wave propagates through space at the boundary between 3D and 4D worlds; it will influence material on this side of the boundary. This will take the form of a 'particle orbital motion' that excites passive photons close to the boundary layer.*

This induced orbital motion will affect material on *this side* of the boundary to a greater or lesser extent and obviously the smaller the particle, the greater the influence. Smaller three-dimensional particles (especially those that have condensed through the attenuation of dim-wave energy) will exhibit a much smaller energy threshold than say the independent boundary chords or the much larger whole surviving teddies. In addition, the smaller the particle, the faster the rate of radiation, just as a red hot pin head will cool more quickly than a red-hot poker. As the dim-wave propagates across the dimensional boundary, those *passive photons* close enough to be affected by particle orbital motion will gain ***spin*** and thus energy. Spin will in turn; be dependent on the direction of propagation and thus the character of this orbital motion (see *Figure 18.3.02* below).

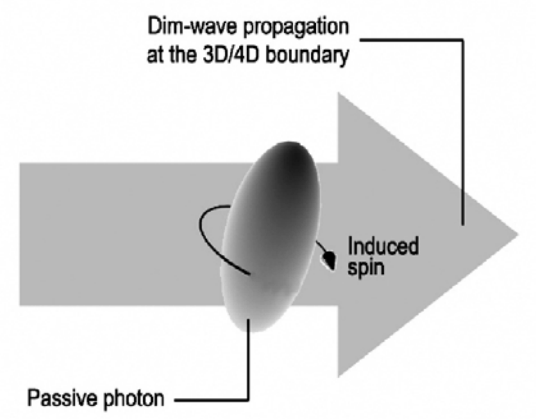

Figure 18.3.02 *As a dim-wave propagates at the 3D/4D boundary, passive photons (themselves attenuated dim-wave energy) may gain spin due to the effects of particle orbital motion.*

From the illustration, it is easy to see that the orientation of the wave's motion will have a direct bearing on the photon's spin direction. If you were to point the arrow to the left instead of the right, the apparent spin of the particle would become counter-clockwise instead of the clockwise direction shown - and this would have some quite profound consequences on the way we currently interpret the nature of the quantum universe. This change in apparent spin direction is what would exactly result from light (or its dim-wave energy) being bounced from a suitable mirror. The illustration in the figure would represent the incoming light wave just before it is reflected; complete with its secondary effect of induced clockwise photon spin. Its reflection however, would involve the same light wave travelling in the opposite direction (or arrow pointing left in the figure) and as a consequence, the apparent spin direction would become opposite or counter-clockwise. While on the subject of this induced photon spin, it looks as though there could be an interesting consequence here for what is known as ***quantum entanglement***. This is a somewhat mysterious and (often called) *wonderful* phenomenon that has been discovered within the bounds of quantum theory; where certain separate, physical systems would seem to become 'entangled'. In a nut-shell, this seems to infer that a particular system's *physical state* is directly related to the state of another system (or object) somewhere else. When measurements are made in any particular, chosen system, it is said that its *Schroedinger wave function* collapses into a single state - while at the same time, the other system also collapses into a corresponding state *regardless* of the distance between them - and this is usually termed ***non-locality***.

18.4 The Rochester experiment

Attempts have been made on several occasions to test this phenomenon and such procedures are usually referred to as *quantum-coherence* or *Bell inequality violation experiments* - as they involve the Bell theorem propounded by the physicist John S. Bell. This states that when measurements are made on any one particular entity, the information obtained must affect the state of a second some distance away and they can no longer be treated as separate, independent bodies.

One such procedure is I believe, known as the *Rochester Experiment* and to quote one Internet source [1]:

" . . . it has been strongly evidenced that a quantum system may respond in an observable way to changes in information, even when that information is obtained without physical intrusion.

The experiment consists of a laser incident upon a beam splitter, along with two sets of mirrors, and down converters. The down converters are special crystals that split a single photon into two, such that the laser beam passing a down converter is split into a signal beam and an idler beam (which in turn corresponds to signal photons and idler photons). Thus, whenever, one of the idler beams is blocked off, we know which way a given signal photon travelled, without ever having directly affected the signal proton. And yet, the diffraction pattern of the signal beams breaks down.

Note that, there is no physical disturbance of the signal beams itself, nor some physical intrusion that caused this change in the outcome of the experiments. The diffraction pattern involves only the signal photons.
The intrusion involves only the idler photons. Signal photons and idler photons never meet again after they leave their down converters and yet, by blocking off the latter, the former are affected. The distinct change in a macroscopic observable phenomenon is seemingly brought about by nothing but the change in information about the system." [1] Information implies mind-like, and thus we encounter in the quantum world, a form of consciousness".

I would not necessarily agree with the last sentence and what it implies, although *quantum consciousness* is quite topical at the moment. The Internet source included a rather sketchy illustration and this has been redrawn as *Figure 18.4.01* below.

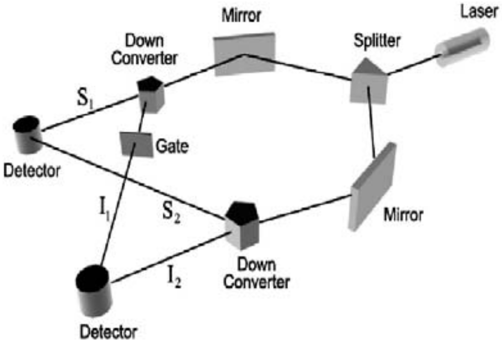

Figure 18.4.01 *The Rochester experiment to test the phenomenon of quantum entanglement.*

The signal beam mentioned in the text is marked 'S1' and 'S2' in the illustration and the idler beam "I1' and 'I2'. The gate is used to block off idler photons without affecting the signal beam although the very act of interrupting the idler beam seems to influence the signal beam's diffraction pattern. However, if one takes the view that photons themselves are not transmitted in the experiment (it's only the laser's dim-wave energy), then a somewhat different conclusion can be drawn from the results. Photons in this instance, will result along the plane of travel as they are stimulated by the propagation of the light wave itself. They are not a single entity, but a series of stimulated particles along the path of the wave, that are replaced by others as the wave progresses.

The energetic photon would have but a fleeting existence as its energy is quickly dissipated. The phenomenon of orbital motion here on earth tends to diminish with depth - in that the orbit of particles gets smaller and smaller the further away they are from the plane of the boundary (water and air or two different densities of rock) and this indicates a fall in the available energy producing this motion in the first place. If this phenomenon is extended to the dimensional boundary too, one can imagine a fall in the energy absorbed by passive photons further away from the plane of propagation (thinking in three-dimensional terms of course). Different levels of excitement would infer different levels of radiation - and thus light's secondary effect could be considered as a series of (secondary) dim-wave energies, the most energetic of which would lie close to the value of the original dimensional boundary surface wave already propagating at the dimensional boundary itself. We would end up with an energy diagram that is perhaps not dissimilar to that provided for hydrogen's single electron, illustrated as *Figure 12.5.05* on page 106. Light's primary and secondary effects would thus produce a series of energies not unlike the definition we commonly give to a spectrum.

Another way of looking at this secondary effect is to treat the particulate characteristic as the attenuation of the dim-wave in real-time. This has already been likened to the deposit of chalk onto a blackboard surface and this chalk-line would represent the condensation of dim-wave energy during attenuation. This would provide the material that becomes the *passive photon* and in this scenario, would be a short-lived energetic particle produced directly from the dim-wave at the dimensional boundary. *Short-lived* in the sense that it remains excited for only a short period of time until its own energy is dissipated and will thus become a cold, silent passive photon until the possibility of its interaction with another passing dim-wave - in which case, it will again absorb energy and produce its own short-lived dim-wave - becoming once again, a short-lived energetic photon if it lies close to the boundary position of a propagating dimensional boundary surface wave of appropriate energy.

Each and every emission of light would produce attenuation and thus a condensation of dimensional energy from the very first proton/proton collision within the young, embryonic universe not long after the big-ping. Over what is perhaps thirty-odd billion years of existence, the universe would have accumulated a heck of a lot of this 'light-dust', which would permeate four-dimensional space, more or less every where. It would sit in the space between the galaxies as well as between molecules, atoms and between nucleus and electron shell. It would be nigh-on impossible at this stage to give it a meaningful overall mass, but a thirty billion year conglomeration of even the minutest amounts would by now, be quite staggering in its proportions. Thankfully for the universe, this added matter does not tend to 'clog-up' the works because of four-dimensional expansion, which would seem to provide the room for this continual influx of matter. Could this add weight to the argument for dark matter? Well, only time will tell.