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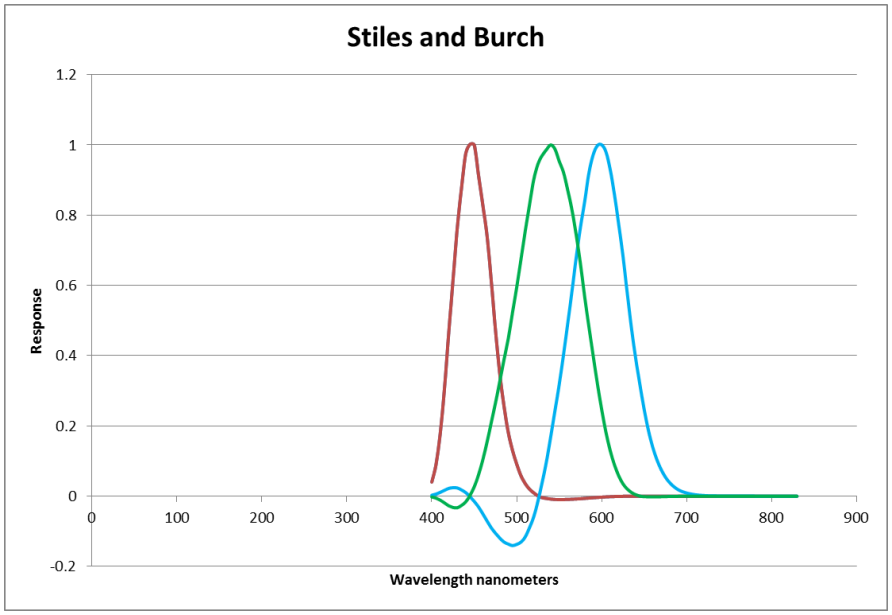
Title: It from Information

Introduction

Feynman's quantum mechanical equation for absorption of light leads to a sharp response as wavelength matching occurs. It appears that our sensory system utilizes this equation and a model of color vision is demonstrated that agrees well with the measured color sensitivity in humans. The manner in which color responses add together into meaningful perception supports the author's view that nature is based on specific information theory probabilities described in the author's FQXi essay [1]. It is speculated that life is an emergent property of chemicals that absorb energy and use information.

Color Vision

Data for the following diagram was downloaded from the Color Vision Research Laboratory at the University of California [6]. It is the Stiles and Burch, red and blue, 10-degree target color matching functions used to characterize cone spectral sensitivity.



Light is the energy released when an electron jumps between orbitals. Quantum mechanics describes the allowable orbits. Absorbed light is characterized by a discrete wavelength associated with the electron oscillating between the second orbital and the third orbital (quantum number 2 to quantum number 3).

N	Binding Energy	Quantum no	Quantum no	Delta Energy	Wavelength
		E2=BE/2^2	E3=BE/3^2	E2-E3	E2-E3
	(mev)	(mev)	(mev)	(mev)	(nanometers)
		2	3		
0.296	1.361E-05	3.40E-06	1.51E-06	1.89E-06	655.9

The equation of interest is a wave function for a system that has an internal freedom that varies back and forth between two frequency (f) values.

Psi=muE0/h (1-exp i (f-F) t/ (f-F))

The solution to this quantum mechanical equation is found in The Feynman Lectures on Physics, Volume III page 9-13 [3]. The basic equation for a probability pf is divided by pF to form a ratio normalized to make the peak response equal to one at the peak frequency, F. This equation will be called the absorption equation.

pf/pF=(sin((f-F)t/2))^2/((f-F)t/2))^2
Where f=frequency and t=time interval.

The absorption equation can also be written in terms of distance (D=C t), instead of time. With MC=f-F=C (1/wl-1/WL) and t/2=2D/C=1/(1/dwl-1/wl) where dwl is the width of the response curve, wl is the incoming wavelength and WL is the peak wavelength. The same equation in terms of D and M follows with (f-F) t/2= M*C/C *(2D) = 2DM. (C, the speed of light, cancels).

pf/pF= (SIN (2MD)) ^2/ ((2MD) ^2

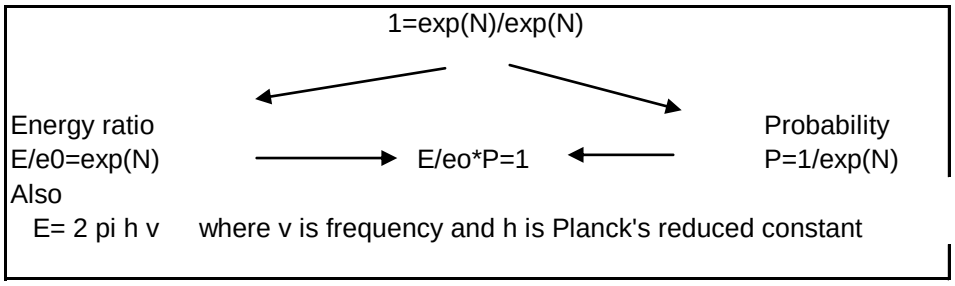
Example calculations for red light at 400 nanometers: M=1/400-1/594.3=8.17e5 meters^-1 and D= 1e-9/ (1/55.8-1/594.3)=5.73e-6 meters (573 nanometers) when the peak wavelength for red light is 594.3 nanometers and the width of the curve is 55.81 nanometers.

	COLOR CALCULATIONS					
dwl	55.8116	meters^-1	meters		pf/PF	
WL	594.334188		D=1e-9/(1/(WL-dwl)-1/WL)			
		M=1e9*(1/wl-1/WL)		2*D*M	(SIN(2*D*M))^2/(2D*M)^2	
wl	400	8.17E+05	5.7347E-06	9.38	2.7501E-05	
	405	7.87E+05	5.7347E-06	9.02	0.00189134	

As wavelength increases to the peak, the quantity (1/wl-1/WL) becomes zero for an instant and probability builds to one. On both sides of WL, the absorption equation gives the response of the eye to that color. pf/pF peaks at one through the sin^2 function.

Information theory probabilities

Reference 1 proposed that nature uses logarithmic values (defined as N=-ln P) to represent information (ln is the abbreviation for natural logarithm). C. Shannon [9] used S=-ln P to represent information and thermodynamics incorporates similar concepts except it is the statistics of many particles. The author's N identifies particles such as an electron and components of the electric field. Dimensionless energy (E/e0) = exp(N) is defined as follows:



In this system, a dimensionless energy ratio is just the inverse of probability. Since wavelength is also the inverse of energy, the probability and a dimensionless wavelength are equivalent.

P=e0/E=(2 pi h v0)/(2 pi h v)=v0/v=wl/wlo.

Reference 1 reported a hierarchical information (Appendix 1) code that gave a meaningful value to e0. Note the use of N=0.0986 in the table that follows with E=e0*exp(N)=2.02e-5*exp(3*0.0986)=27.2e-6 mev. The value 0.0986= ln(3/exp(1)) is associated with charge including fractional charge of quarks. Of course 27.2e-6 mev is just the electromagnetic potential (twice the binding energy). With the value e0=2.02e-5, wl0 equals 655.93 nanometers (1.89e-6 mev).

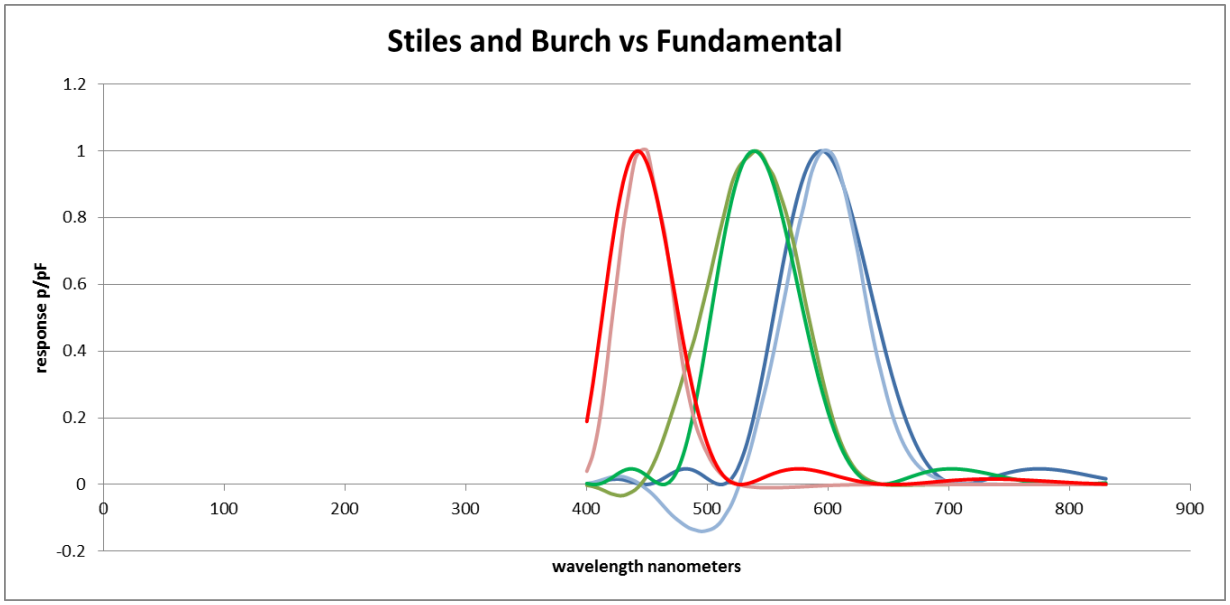
The rods in our eyes have a response curve between the blue and green peaks and its peak is included above. The table below shows that the wavelengths the eye sees as red, green, rod and blue are separated by N=0.0986. For example information N=0.0986, P=1/exp(.098)= 0.906 and wl/wl0=594.3/655.9=0.906. It specifies the shift in wavelength from wlo=655.9 nm to the other wavelengths by the series 1,2,3,4x0.0986. Each meaning is associated with a wavelength and pf/pF peak intensity.

0.098612289							Perceived meaning (differentiator)				
20.24715467		(E0/E)		wavelength							
4.13567E-21		wl/base		(nm)			Meaning	Blue	Scotopic	Green	Red
			base		Normalized						
n	n*.0986	P=1/exp(n*.0986)			P/Pf0		Code				0.906
1	0.0986123	0.906	655.92999	594.334		1	R			0.821	
2	0.1972246	0.821	655.92999	538.523		1	G				
3	0.2958369	0.744	655.92999	487.952		1	S		0.744		
4	0.3944492	0.674	655.92999	442.130		1	B	0.674			
								Blue	Scotopic	Green	Red
							Overall response is white light				

The width of eye's sensitivity to a particular color is specified in another way by N=0.0986. Note in the table below that difference in energy (D Energy below) between each level can be converted to the delta wavelength series 61,51,50,45, etc. These give the width of the pf/pF response curves.

	N Series	Energy (Mev)		Probabilty	D Energy	WIDTH (nm)	PEAK	D	Color
Electron	-0.10454	1.8237E-05		& natural wavelength					
Electron	-0.00593	2.0127E-05	base		1.89009E-06	**61.60**	**655.93**	**6.33E-06**	
Electron	0.09268	2.2213E-05	0.0986	0.906	2.08597E-06	**55.81**	**594.33**	**5.73E-06**	Red
Electron	0.19129	2.4516E-05	0.0986	0.821	2.30216E-06	**50.57**	**538.52**	**5.20E-06**	Green
Electron	0.28991	2.7056E-05	0.0986	0.744	2.54075E-06	**45.82**	**487.95**	**4.71E-06**	Scotopic
Electron	0.38852	2.9860E-05	0.0986	0.674	2.80407E-06	**41.52**	**442.13**	**4.27E-06**	Blue

The eyes measured response to light from Stiles and Burch compare favorably with the Feynman equation for absorption of light using the N series 0.0986. The graph below plots the Feynman equation pf/pF for the three color peaks 594, 538 and 442 nanometers. The associated width series was 61, 55 and 41 respectively for red, green and blue responses. These are tentatively called fundamental since they appear to follow the information series.



The fundamental calculations are the lighter colors and the dark colors are Stiles and Burch.

The explanation for color vision being sensitivities to different wavelengths based on N=0.0986 is surprising and new. The author followed up on this finding. Rather than four full distinct pf/pF responses, we see white light and this indicates that our human color vision system is operational and stringing together meanings. The other hues are comprised of combinations of these colors without full spectrums and it clear that the brain is adept at creating meanings from these curves. Other senses have different multi-wavelength responses (the ear for example).

Appendix 3 discusses the small difference between the above responses. Overall, the dye (or dyes) absorbs throughout the approximate range 400 to 700 nanometers. There are four signals that come from the pf/pF functions associated with the dyes that aid absorption [4,5]. Partially processed signals from the retina go into the brain where a great deal of processing takes place.

The nerve connections leading from the eyes to the brain are well characterized in the literature. It is known that the nerves convey ions and it is clear from the connections that signals are added and subtracted. Focus of how our brain uses and interprets (perceives) these signals. Based on the above, the signals to be processed are probabilities. The following table shows a few pf/PF intensities for short wavelengths. For example, the probability associated with 400 nm is 0.609 when it is normalized by the divisor 655.9 nm and the red intensity is 0.003). The author believes the brain uses information (N=-ln(P)) based on these probabilities.

Wavelenth (wl)	Probability	intensity		intensity		intensity		intensity		Sum
Nanometers	wl/655.93	red		green		rods		blue		(white)
		Pr(H)	Pr(H/E)	Pr(H)	Pg(H/E)	Pr(H)	Ps(H/E)	Pr(H)	Pb(H/E)	P(H/E)
395	0.6022	0.003	1	-0.002	1	0.04	1	0.04	1	0.085
400	0.60982	0.006	1	-0.006	1	0.03	1	0.09	1	0.125
405	0.61744	0.011	1	-0.011	1	0.02	1	0.18	1	0.199
410	0.62507	0.017	1	-0.019	1	0.01	1	0.31	1	0.312
415	0.63269	0.022	1	-0.027	1	0.00	1	0.47	1	0.462
420	0.64031	0.024	1	-0.032	1	0.01	1	0.62	1	0.617
425	0.64793	0.024	1	-0.033	1	0.04	1	0.76	1	0.793

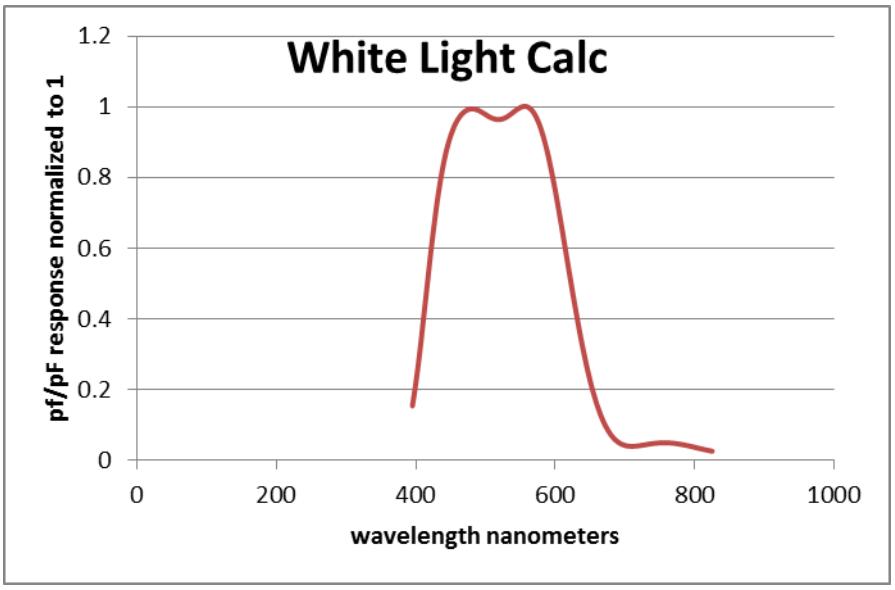
Recall that our eye responds in a logarithmic manner to brightness. Also, it is known that the amount of neurotransmitter decreases with increasing light intensity. Note what happens to the value T=-ln(P) as P increases.

P	T
	neg LN(P)
0.1	2.3025851
0.2	1.6094379
0.3	1.2039728
0.4	0.9162907

According to Stanislas Dehaene [7], it is thought that the brain operates on Bayesian probabilities. The equations of interest are of this type: p(H/E)=p(E/H)/p(E)*p(H). Wiki defines the terms as p(H/E) as the posterior belief and p(E/H) as the probability of the evidence given a prior belief, p(H) as the probability of the prior belief and p(E) as the marginal likelihood. When the eye receives light, ions leave the eye and are transported along the axion taking the value of the normalized wavelength (probability) and its intensity to the brain. There are different nerves associated with the three colors and the rod response so there are four intensity values for each normalized wavelength. The brain receives the intensity (height of the p/pF function for each wavelength) and does not have to recreate the p/pF function to interpret the above data (think of the eye as a sensor that has already translated light into signals). The brains task is to assign meanings to new data signals based on stored information within existing brain cells in the visual cortex. The information stored in the brain is p(H) (the prior belief and expected signal value) and p(E/H) is the new evidence probability (signal) coming from the eye. In this model, p(E) is a probability that normalizes the data as the signal is updated and the brain gains believable evidence.

The goal of the calculation is to find the value p(H/E), the probability of the evidence updating the stored prior belief. Our brain perceives the sum of p(H/E) values over four signals across the wavelength range.

The mind expects white light (the full pf/PF curve for four signals) and p(H) is the prior belief color intensity for each signal at a particular wavelength. For example in the first line of the above table, the pf/pF function gives a p(H) value of 0.003 for red light, -0.0002 for green, 0.04 for rod response and 0.04 for blue. If the evidence intensity signals p(E/H) reaching the brain are the expected values, p(E/H) will be 1. This means that each of the p(H) values is multiplied by 1 and p(E/H) for the sum of the four values at 395 nm will be 0.086. This same process occurs for each wavelength and if each color is full spectrum, the following curve will be produced. Our brain will interpret this as white light. This is made possible because the four color probability values are spaced N= 0.0986 apart.



Note that the above calculation requires a multiplication and a division, p(H/E)=p(H) x p(E/H)/p(E). The calculation is probably aided by the basis of the author's work that probabilities are fundamentally information represented by the value N=-ln P. Based on logarithmic math, when nerve signals are added, probabilities are being multiplied and when nerve signals are subtracted, probabilities are being divided. When colored light is received (incomplete spectrums for the four components), the evidence p(E/H) is not equal to the expectation value p(H) and the probability updated for evidence p(H/E) will not be 1. This skews the results into the various hues and colors our brain actually sees.

Now recall of course that the eye is actually transmitting color images and the visual cortex is a wired to receive the images. Shape recognition is reported extensively in the literature [8]. As an example, assume that a moving yellow spherical object is being observed by the eye. The

brain has already used stored information regarding the circular edge and color to identify it as a tennis ball (the P(H/E) probability for this attribute is near 1). As the object comes closer to the observer, nerve signals are sent to the eye and muscles to track the ball. This integration occurs rapidly because the brain has already assigned high attention to these signals and is experienced at tracking tennis balls.

It from bit?

We know that thermodynamic entropy is increasing overall but life absorbs energy and uses information to exploit thermodynamic entropy locally. It appears to the author that perception accompanies energy gain and it is proposed that this leads to associated molecules with a primitive identity. Exploitation of the identity's energy and information gain across deep time apparently leads to the thriving and replicating chemical system that we call life. This is fundamental in the author's view because probability P and normalized wavelength are equivalent, normalized wavelength is inverse energy and information N=-ln P. Overall, it from bit is correct but the author might substitute the word information for bit.

One doesn't have to accept the author's information code to understand that nature is adept at building information systems from, well, information. However, it allows one to understand that physics is an Information based science. Reference 1 used WMAP data to estimate the number of particles in the universe Number=exp(180). This makes the probability of one particle the value P= 1/exp(180) and information N=-ln(1/exp(180))=180. Reference 1 attempts to explain how nature differentiates the information value 180 into its basic particles and forces. The intent of reference 2 is to show how specific information values apply to cosmology.

References

1) Barbee, E. H., FQXI essay, Top-Down Approach to Force Unification, June 2012.
2) Barbee, E. H., Application of proton mass model to cosmology, post in June essay contest, July 2012.
3) Feynman, R.P., Leighton, R.B., Sands, M., The Feynman Lectures on Physics, Addison-Wesley, 1965.
4) Sharpe, L. T., Nathans, J., Jagle, H., & Stockman, A. (1995). Red and red-green hybrid pigments in man. Investigative Ophthalmology and Visual Science (supplement), 36, S208.
5) Sharpe L. T., Stockman, A., Jägle, H., & Nathans, J. (1999). Opsin genes, cone photo pigments, color vision and colorblindness. In K. Gegenfurtner & L. T. Sharpe (Eds.), Color vision: from genes to perception (pp. 3-50) Cambridge: Cambridge University Press
6) www.cvrl.org/stilesburch10_ind.htm
7) Brockman, John, This Explains Everything, 2013. Article by Stanislas Dehaene, The Universal Algorithm for Human Decision Making.
8) Brockman, John, *This Explains Everything*, 2013. Article by Gerd Gigerenzer, *Unconscious Inferences*.
9) Claude Shannon, *A mathematical Theory of Communication*, 1948.

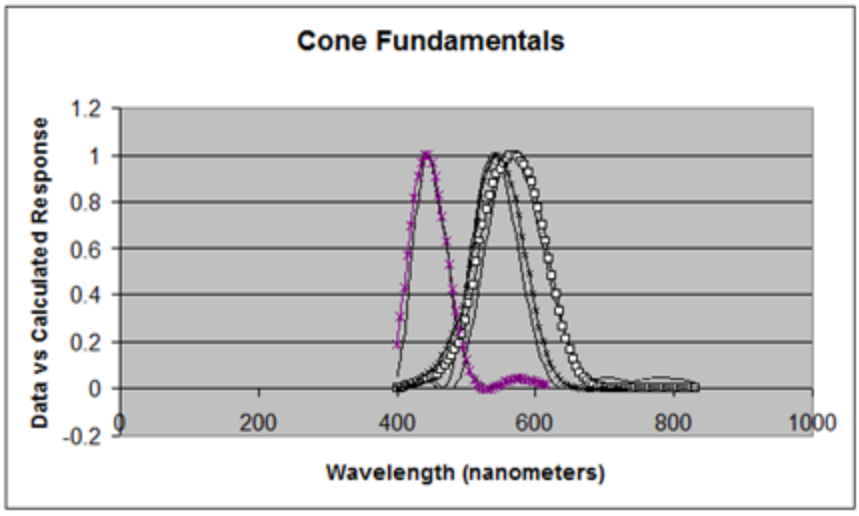
Appendix 1

The author's decoded particle energy hierarchy from reference 1 is included for reference.

Particle review									
unifying concepts.xls cell aw48				Proposed					
		Particle Data	PDG	Energy	IS Hughes	Bergstrom	Randall	Best	N difference
		Group energy	charge	E=eo*exp(N)	energy	energy	energy	data for	(proposal-
Identifier	N	(Mev)		(Mev)	(Mev)	(Mev)	(Mev)	N Value	best data)
0.0986 ener	0.099								
e neutrino	0.000	2.00E-06		2.02E-05	1.50E-07	3.00E-06		-2.31486941	
E/M Field	0.296	0.0000272		2.72E-05				0.295200381	0.000636485
							0.0011		
ELECTRON	10.136	0.51099891	-1.00	0.511				10.13610614	2.61223E-06
mu neutrino	10.408	0.19		0.671	less than 0.25			9.146762759	1.261563509
Graviton*		1.75E-26		2.683					
Up Quark	11.432	1.5 to 3	0.67	1.867		1.5 to 4.5	2.4	11.6829627	-0.251017081
vt neutrino	12.432	18		5.076	less than 35	18			
Down Quark	13.432	3 to 7	-0.33	13.797		5 to 8.5	4.8	12.37610988	1.055835738
	16.432			277.120					
Strange qua	15.432	95+/-25	-0.33	101.947		80 to 155	104	15.45188486	-0.019939243
	16.432			277.120					
Charmed Q	17.432	1200+/-90	0.67	753.29		1000 to1400	1300	17.97761351	-0.545667887
Bottom Qua	19.432	4200+/-70	-0.33	5566.11	4220	4000 to 4500	4200	19.15033377	0.281611852
Top Quark	21.432		0.67	41128.30		40000	171200	21.4041287	0.027816923
W+,w- boso	22.099	80399	-1.00	80106.98	81000	80000	80400	22.10225098	-0.003638694
Z	22.235	91188	0.00	91787.1	91182	91000	91200	22.22817255	0.007
HIGGS	22.500	125300		119671.5		105000		22.54596011	-0.046
* sum of 3 N's of 10.431 and one 10.333 and graviton is 2.68/exp(90)=1.59e-38 mev.									
Mw/Mz	Weinberg radians		sin^2 theta						6.3432E-11
0.87274771	0.509993439	0.48817152	0.238311				6.674E-11		6.3263E-11

Appendix 2

The graph on the following page shows results from the Feynman equation plotted against data from the CVRL web site [6] entitled "Cone Fundamentals". There are small differences between the actual measurements for the eye and the calculated absorption. Absorption in the human eye is aided by the dye rhodopsin, which absorbs throughout the wavelength range 400 nanometers to 700 nanometers and the differences may be associated with the spectral sensitivity of rhodopsin. The literature reports that rhodopsin has isomers that absorb light in at least two colors related to amino acid variations. As one can see from the graphs below, these calculations closely match the measured sensitivity of the human eye to color. The calculated curves are marked with xs and boxes.


Cone Fundamentals
Data vs Calculated Response
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
200
400
600
800
1000
Wavelength (nanometers)