THE ATTENUATION OF VISIBLE RADIATION IN THE VAPOR CANOPY

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A common objection to the vapor canopy theory has been that an extensive vapor blanket would attenuate all incoming starlight. In the following discussion, a vapor canopy model containing vapor amounting to forty feet of precipitable water is proposed. The physics of the maintenance of this amount of water has been developed and will be the subject of a later publication. The scattering coefficient of the vapor canopy is calculated and some approximations are made on the visibility in the pre-flood heavens. In conclusion, some suggestions are made regarding the effect on ancient mythology of the change in the appearance of the sky after the flood.

A frequent objection raised against the vapor canopy hypothesis is that such a quantity of precipitable water in the atmosphere would result in the total eclipse of all starlight.[1] Indeed, a canopy containing water amounting to thousands of feet of liquid would do so, no matter in what form the water was.[2] (Actually, a liquid canopy would attenuate less than one containing the same amount of water in the form of vapor.) But a canopy containing a moderate amount of water, in the form of vapor, would not have any drastic optical effect, as will be shown here.

For definiteness, it will be assumed that the canopy contained water vapor equivalent to forty feet of liquid. That rather arbitrary figure is chosen on these grounds: it would provide rain at the rate of one half inch per hour, which is a quite heavy rain, for forty days at the beginning of the flood; and it would still leave many stars visible.

Some Stars Were Visible Before the Flood

Since the Genesis account seems to indicate that men *were* able to see the stars, it would seem that the thickness of the canopy could not have been such that it would cause the extinction of all star light. (Gen. 1:16). It has been suggested as a way around this objection that the stars did not become visible until after the flood; they were only *created* (but not visible) on the fourth day. However, in view of the fact that men were clearly able to calculate time in years, and months, the sun and the moon must have been visible (Gen. 5). Since Genesis 1:14-17 makes no distinction between the visibility of the various luminaries, and since the sun and the moon are declared or implied to be visible, it seems more natural to assume that Moses intended to teach that the stars also were visible to Adam. It is only the physical problems involved if starlight is to penetrate such a vast vapor blanket as some have imagined that would cause one to entertain this unlikely interpretation. Hence, the question remains: What would be the effect of the proposed forty feet of precipitable water distributed throughout many miles of a thermal vapor blanket on the appearance of the antediluvian heavens?

The Magnitude of Starlight

Astronomers traditionally posit six magnitudes of star on the basis of the visibility of stars to the naked eye. This classification was made on the basis of visual observations by ancient Greek astronomers. A magnitude of "1" was the magnitude of the *brightest star* visible to ancient stargazers, and a magnitude of "6" is the dimmest. With the advent of modern telescopes, greater precision has been introduced into this scheme. It was found that the ancient classification fell into a nearly perfect geometrical series, the ratio of intensities between magnitudes being about 2.5:1. This ratio between magnitudes has been officially standardized at $(100)^{0.2}$:1, or about 2.512:1.[3]

A 100-watt bulb held 6.25 miles away has the same visual intensity as a star of the first magnitude.[4] The sun has a visual magnitude of −26.72[5] (The negative sign is used to extend this system to describe the magnitudes of celestial objects having much brighter intensities than 1.) Thus, the brightest (fixed) star, Sirius, has a magnitude of −1.6, instead of 1, under this standardized system.[6] Modern telescopes have now pulled in stars[7] whose magnitude is +24. This system gives the relative intensities of starlight as it appears to the human eye. Thus, a star of the first magnitude is 2.512 times as bright in appearance as a star of the second magnitude, and 100 times, exactly, as bright as a star of the sixth magnitude. A simple equation for the relationships between star magnitudes is as follows:[8]

$$\frac{I_2}{I_1} = 10^{0.4\Delta m} \quad \Delta m = m_1 - m_2 \qquad (1)$$

where m_1 and m_2 are the visual magnitude numbers and the I_1 and I_2 refer to the relative intensity of the starlight from stars of those magnitudes, usually expressed in lumens per unit area. Table 1 gives the relative intensities and numbers, of the six magnitudes of visible stars. Thus, a star of magnitude 3 is only 0.16 times as bright in appearance to the human eye as a star of magnitude 1, and so on.

In order to get a kind of practical grasp as to what these numbers mean, consider the following comparisons. The full moon[10] has a magnitude of −12, and

Table 1. This shows the relative intensities of the light from stars of the various visual magnitudes, and the number of stars of those magnitudes. See also Reference 9.

Visual Magnitude	*Relative Intensity*	*Number of Stars of that Magnitude*
1	1.00	20
2	0.40	65
3	0.16	200
4	0.063	500
5	0.025	1400
6	0.010	5000
		Total 7185

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the sun, having a visual magnitude of −26.72, is therefore 772,680 times brighter than the moon. A value quoted for the illuminance of a 0 magnitude star is 2.54×10^{-10} lm/cm^2 (incident intensity at the top of the earth's atmosphere).[11] This is equivalent to 2.36×10^{-7} lm/ft^2 (i.e., foot candles). The sun, on the other hand, has an incident intensity at the top of the atmosphere of about 12,000 foot candles.[12] Thus, the sun is 5×10^{10} times brighter than a zero magnitude star.[13] A 100-watt incandescent lamp at a distance of one foot gives about 150 ft-candles.[14] Table 2 gives some comparisons of intensities of various sources. (There may be some discrepancies among the figures given here; for they are from various compilations, in which somewhat different conditions may have been assumed. But the figures will serve to indicate the orders of magnitude involved.)

Table 2. This shows the luminance, i.e. strength of light received, from various sources of light. For comparison, their magnitudes also are calculated, according to the same formula as that used for stars. For the astronomical sources, this refers to light received at the earth; for the other sources, at a typical distance. See also Reference 15.

Source of Light	*Visual Magnitude*	*Approximate Average Luminance (cd/metre²,)*
Sun	−26.72	160,000.00
Moon	−12.00	0.25
Flashbulb	−24.01	16,000.00
Candle	−13.50	1.00
Fluorescent Lamp	−13.28	0.82
Sirius (brightest star)	−1.6	9.12×10^{-7}

It may be mentioned that the total light of all the stars in the heavens is equal to that of 1,092 stars of visual magnitude 1.0.[16]

A final point needs to be emphasized. The eye has different levels of sensitivity to different wavelengths (i.e., colors) of the visible electromagnetic spectrum. The visible spectrum ranges from about 4000 Angstroms to 7000 Angstroms. (An Angstrom unit, indicated by *A*, is 10^{-8}cm.). The 7000 *A* end of the spectrum approaches infrared radiation (heat) and the 4000 *A* end of the spectrum approaches ultraviolet (the kind of light that produces a suntan). The eye is nearly 100 times as sensitive to yellow-green light (5500 *A*) as it is to far red or violet.[17]

For this reason, one's judgement of brightness depends largely on the yellow-green, even though the stars radiate all wavelengths. Magnitudes measured with the eye are called visual magnitudes; the eye responds most readily to the yellow-green light of the stars.[18] The average wavelength of visual magnitude from the stars is 5280 *A*,[19] i.e., the visual magnitudes correlate with the intensities of light of that wavelength.

The Attenuation of Starlight

As starlight penetrates the atmosphere, its intensity is reduced (attenuated) by absorption and scattering. The importance of absorption on visible radiation is relatively insignificant and can be neglected.[20] Scattering, however, is very important and is of two basic kinds: Rayleigh and very small particle (aerosols). Both of these scattering phenomena obey Beer's law:[21]

$$I = I_0 e^{-KL(\sec\theta)} \qquad (2)$$

(Strictly, this relation is what would apply were the Earth flat. However, it is a sufficiently good approximation to the true situation.) Here I_0 is the "incident" intensity of the starlight at the top of the earth's atmosphere; I is the resultant intensity after going a distance L through the medium (see Figure 1); and θ is the angle from the vertical (zenith) at which the light ray enters the atmosphere. (see Figure 2.) The term, KL, is called the "optical depth" of the medium. The equation for the coefficient of Rayleigh scattering, K, for a gas, is given by[22]

$$K = \frac{32\pi^3}{3N\lambda^4}(n - 1)^2 \qquad (3)$$

where N = the number of molecules/cm^3; λ = wavelength in centimeters, and n = the refractive index. Since[23] the term $(n - 1)$ is directly proportional to N, so is K. The Rayleigh coefficient is inversely proportional to the fourth power of the wavelength. It is this strong wavelength dependence of K that causes the sky to appear blue and sunsets red. When λ is large, KL is small and there is less scattering.

Thus, at the 7000 *A* (red) end of the spectrum there is less scattering than there is at the 4000 *A* (blue) end. Hence, blue light is scattered to a much greater extent by the air molecules, and the sky is blue. As the optical path of the light ray increases, blue light is scattered so much that very little remains in direct sunlight compared with the red wavelengths. This is why the sun appears red close to the horizon. "The ratio for blue light at 4250 A to that for red light at 6500 A under the same conditions would be $(650/425)^4 = 5.48$. Thus, the scattering of blue light is 5.48 times the scattering for red light."[24]

> Sunlight, which is basically white, often reaches the earth with a reddish tinge. This is especially noticeable at sunset when the light passes through its longest path of atmosphere, and is explained by the fact that the blue light has been scattered by the

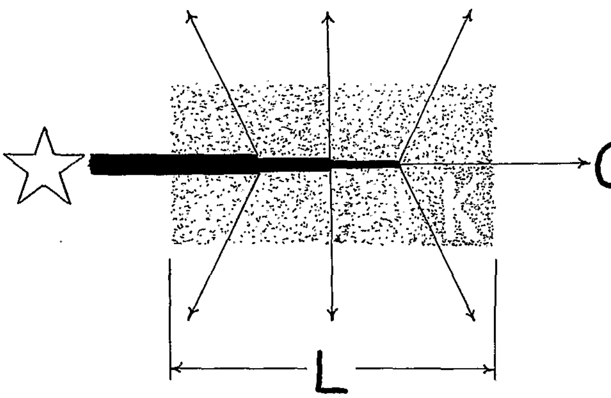

Figure 1. When light from a source, e.g. a star, goes a distance *L* through a medium characterized by a coefficient *K*, some of the light is scattered in various directions, as shown, and only a fraction gets through to an observer at O.

atmosphere and only the reddish portions reach us directly . . . . On the earth, scattering is the process mainly responsible for reducing the visibility or distance from which objects can barely be seen. Under hazy or dusty conditions the light from a distant object may be completely attenuated by scattering before reaching the eye. Direct absorption by the haze particles is of some importance, but scattering is the main effect.[25]

When K is directly proportional to the density of the attenuating medium, it follows that the denser the medium, the larger KL will be and hence the greater the scattering. This indeed holds true for gases. However, when water is in the liquid phase, its molecules are more highly ordered and interact less frequently with a penetrating beam of light; thus, it is actually easier for light to penetrate water in the liquid phase. This will be demonstrated later.

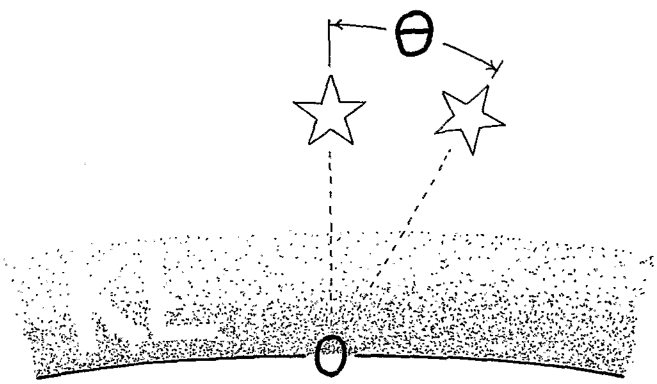

Figure 2. Light from a star at a zenith angle θ goes a greater distance through the air to an observer at O than that from a star directly overhead. An attempt has been made to suggest the curvature of the Earth, but the drawing is not necessarily to scale. Acutally, the approximation of a flat Earth would work sufficiently well here.

In order to calculate the optical depth of the pre-flood atmosphere, which is assumed to contain the gases of the present atmosphere plus water vapor amounting to 40 feet of liquid, the optical depth of the water vapor must be added to the optical depth of today's atmosphere. The optical depth for Rayleigh scattering (i.e., the Rayleigh optical depth or optical depth of a Rayleigh atmosphere) has already been worked out for the standard atmosphere at all wavelengths. The KL_p(for λ = 5280A) of the present atmosphere with aerosols present[26] is 0.346. For an approximation for the pre-flood troposphere this value will be used, even though the aerosol levels of the pre-flood atmosphere were probably considerably lower.

Above the pre-flood troposphere was the vapor canopy. It is now necessary to derive an expression for the KL of the vapor canopy. It will be helpful it this can be done as a function of the amount of precipitable water in the canopy and independent of any particular temperature, pressure, or density distribution. John R. Baumgardner suggested the following derivation.[27]

To find the optical depth KL, the expression for the Rayleigh scattering coefficient (3) is integrated over the optical path through the canopy. Thus,

$$KL = \int_{\substack{opt.\\path}} \frac{32\pi^3(n-1)^2}{3N\lambda^4} dx \qquad (4)$$

where n is the local index of refraction of water vapor, λ is the wavelength in cm(5280×10^{-8}), and N is the local number density in particles/cm³. It is desired to derive an expression for KL in terms of ω, the centimeters of precipitable water in the canopy.

Change the variable of integration from distance x through the vapor to distance ω through an equivalent depth of liquid water. The conversion factor would be

$$\frac{dx}{d\omega} = \frac{\text{density of liquid}}{\text{density of vapor}} = \frac{1\ \text{gm/cm}^3}{\left[\dfrac{(18.0153\text{gm/mole})}{(2.24 \times 10^4\text{cm}^3\text{/mole})}\right][N/N_{STP}]} =$$

$$1.243 \times 10^3 N_{STP}/N \qquad (5)$$

where N_{STP} is the number density of a gas at standard temperature and pressure (STP). Furthermore, the term $(n-1)$ is proportional to the number density N, and at STP for water vapor it has the value 2.54×10^{-4}.[28] Therefore, one may write (4) as

$$KL = \frac{32\pi^3}{3\lambda^4} \int_{\substack{optical\\path}} \frac{[(2.54 \times 10^{-4})(\frac{N}{N_{STP}})]^2[(1.243 \times 10^3)(\frac{N_{STP}}{N})]\, d\omega}{N} \qquad (6)$$

and observe that the number density dependence cancels inside the integral. With N_{STP} = Avogadro's number/molar volume [5] 2.69×10^{19} particles/cm³ (i.e., $6.0238 \times 10^{23}/2.24 \times 10^4$), one obtains $KL = (32\pi^3\omega/3\lambda^4)(2.54 \times 10^{-4})^2(1.243 \times 10^3)/(2.69 \times 10^{19}) = 1.269 \times 10^{-4}\omega$. If the canopy contains 40 feet of precipitable water, ω = 1219 cm, and the optical dpeth of the canopy KL_c = 0.155.

It seems reasonable to suppose that when God lifted up the water above the firmament it was pure water with no aerosols present. If this is so, the canopy would have been pure water vapor with no particulate matter. However, because of ionization of the water vapor and some meteorite dust, probably some aerosols accumulated in the canopy. True aerosols are particles with a radius of about 3×10^{-4}cm; those larger than that will settle out.[29] Meteoritic dust is generally that size or larger. Thus, it would either settle out of the canopy or in most cases burn up as it hit it and never get through.

The only kinds of particles that will produce condensation are called hygroscopic, that is, those substances that have a chemical affinity for water. Condensation will first occur on large hygroscopic particles. Meteoritic dust is non-hygroscopic and hence would not precipitate the canopy. However, meteoritic dust and small ions (i.e., particles with a radius less than 2×10^{-6}cm) would be found in the canopy and would have some effect on Rayleigh scattering.

In the present atmosphere, the KL_p of a pure Rayleigh atmosphere is increased by 0.23 to account for the presence of aerosols. Thus, while the computed value for a Rayleigh atmosphere is 0.116, a value of 0.346 or 0.35 is used.[30] Since there was then no industrial pollution, lower winds, and high humidity, it will be assumed that the aerosol level of the canopy was less than 50% of today's aerosol level. Thus, 50% of 0.23 = 0.115, will be added to the computed canopy KL_c for a generous approximation.

The total optical depth for the canopy including aerosols would then be 0.155 + 0.115 = 0.27, yielding a *KL* for the pre-flood atmosphere of: $KL_t = KL_p + KL_c$ = 0.346 + 0.27 = 0.616.

A Liquid Canopy Compared

For purposes of comparison, the attenuation that would occur if the canopy had remained in liquid form may now be calculated. The expression for the Rayleigh coefficient for water in its liquid phase is given by,[31] $K = 24\pi^3 N(n^2-1)(n^2+1)^{-1} V^{-2}\lambda^{-4}$ where *N* is the number density of liquid water at *STP* = Avogadro's number divided by the gram molecular weight of water or $6.0225 \times 10^{23}/18.0153 = 3.43 \times 10^{22}$ particles/cm^3. *V* the volume of a water molecule is given by $4/3\pi r^3$, where r is the radius of a water vapor molecule or 1.442×10^{-8}cm.[32] Solving for *V*, one gets 1.258×10^{-23}cm^3. The term, *n*, refers to the index of refraction of liquid water at *STP* = 1.33348.[33] Thus, for a wavelength of 5280×10^{-8}cm, $K = 3.97 \times 10^{-5}$. Since L = 40 ft. or 1219cm, KL_c for a liquid water canopy would be 0.0484. Thus, it is apparent that water in the liquid from will attenuate less radiation of this wavelength (5280 *A*) than water in the vapor phase. The *KL* of a vapor canopy is 0.155/0.0484 = 3.2 times as great as the *KL* of a liquid canopy.

Some Stars Would be Seen Through the Proposed Canopy

All starlight (5280 *A*) will not be eclipsed by Rayleigh scalltering[35] until *KL* approaches 4.605. Thus, before all starlight would be eclipsed by the *vapor* canopy, vapor amounting to over 1071 feet of liquid would have to be placed above the pre-flood troposphere (for visibility from directly overhead),[35] in contrast to the 40 feet assumed here.

Visibility in the Pre-flood Heavens

What did Adam and Noah see when they looked up into the night sky or gazed at the daylight sun under canopy conditions? Some rather interesting phenomena may have marked the antediluvian heavens. From (2) it is clear that the attenuation of the starlight will vary with the zenith angle. For the simple case of light coming in directly from above (zenith angle = 0), *KL* = 0.616, as calculated above. Thus, the pre-flood intensity, I_{pf}, is related to the intensity $I_o$incident of the top of the canopy by $I_{pf}/I_o = e^{-0.616}$ so $I_{pf} = 0.54 I_o$. In other words, the light of wavelength 5280 *A* seen by Adam was only 54% as bright as when it entered the top of the pre-flood canopy.

Since the optical depth of today's atmosphere is about 0.35, the present-day intensity I_p is 0.70 I_o, so $I_{pf} = 0.77 I_p$.

Table 3. This shows the relative intensity of stars of various magnitudes, and number of stars of the respective magnitudes visible today. The figures in the third column, being 0.77 times those in the second, show the intensities before the Flood, relative to the situation today.

Magnitude	*Relative Intensity*	*Adjusted Pre-Flood Intensity*	*Number of Stars Visible Today*
1	1.00	0.770	20
2	0.40	0.306	65
3	0.16	0.123	200
4	0.063	0.049	500
5	0.025	0.019	1400
6	0.010	0.008	5000

From this, the following adjustments in star magnitudes relative to today would have existed on the pre-flood earth as shown in Table 3. The dimmest start visible are those of the sixth magnitude where their relative intensity is 0.010. Hence, on the adjusted intensity scale which gives the pre-flood starlight intensity relative to today, any stars which are less than 0.01 will not be visible. This means that only 6th magnitude stars were always obscured on the pre-flood earth. All of the rest of the stars would be visible, at least under some conditions.

On moonlight nights, only stars of magnitudes 1-4 are regularly visible today.[36] Hence in Table 1, the 7185 potentially visible stars are actually visible only under the most ideal conditions of no moon backlight. Therefore, stars of relative intensity 0.025 and dimmer are often not visible today. A look at the adjusted intensity scale reveals that 0.025 falls between the 4th and 5th magnitudes on the pre-flood earth also. Hence, the pre-flood sky would have looked approximately like today's at times of full moon. When the moon is dark today, about 2500 stars are visible at one place and time.[37] (One can view only half the sky at one time. Also, the optical depth is greater near the horizon, causing dimmer stars not to be visible there.) If the same percentage applied to the antediluvian heavens, 34%, this means that on a clear night with no moon, Adam, potentially, could see any of 34% of all stars of magnitudes 1-5 or 34% × 2185 = 743 stars. At any one time, however, only those of the 743 which were high enough in the sky would be actually visible.

Visibility at Various Zenith Angles

In the above discussion, it was assumed that the zenith angle was zero, i.e., only starlight coming in from directly above was considered. Now the effects of various zenith angles must be considered. See Figure 2.

It is obvious from (2) that as the zenith angle θ increases, the optical depth *KL* (*sec* θ) will increase. Now since a hundred-fold increase in scattering will reduce a first magnitude star to sixth magnitude, that is, to the limit of visibility, it follows that an increased optical depth which satisfies the relation, $e^{-KL(sec\theta)} = 0.01$ will yield the value of *KL* for extinction of all starlight by the earth's atmosphere. This relation is satisfied when $KL(sec\ \theta = 4.605$. Now, at what zenith angle, θ, will this occur? Since the pre-flood *KL* was calculated to be 0.616 and the present *KL* = .35, an increase in optical depth of 4.605-0.266 = is needed.[38] Thus, $sec\ \theta_{ext}$ =

Table 4. To reduce a star of magnitude m to invisibility, its effective magnitude would have to be reduced by the amount shown in the second column; this corresponds to reducing its intensity to the fraction shown in the third column. The fourth column shows the increase in optical depth necessary to reduce a star of the magnitude concerned to invisibility. The fifth and sixth columns give θ_{ext}, the greatest zenith angle at which a star of the magnitude concerned would be visible, both under the canopy and today. The angles in the seventh column are the least angles above the horizon at which the stars would be seen. They are ninety degrees minus the angle in the fifth column. All angles are in degrees.

m	$6-m$	$10^{-0.4\Delta m}$	*Increase in Optical Depth for Invisibility*	θ_{ext} *Canopy*	θ_{ext} *Today*	*Angle Above Horizon Under Canopy*
1	5	0.010	4.339	82	86	8
2	4	0.025	3.422	80	85	10
3	3	0.063	2.499	76	83	14
4	2	0.158	1.579	67	80	23
5	1	0.398	0.655	20	68	70

4.339/0.616 = 7.043, and θ_{ext} = 82°, where θ_{ext} = the extinction zenith angle. This means that no stars at a greater distance than 82° from the perpendicular would be visible (i.e., no stars 8° or less above the horizon.) As the zenith angle decreases, more and more stars would come into view as the vertical is approached. Table 4 presents the angles at which stars of various magnitudes will come into view. The starlight of each magnitude will be eclipsed when the optical path is such that it will reduce the starlight of that particular magnitude to the intensity of the sixth magnitude.

As mentioned above, an increase of the optical depth to 4.605 will reduce a first magnitude star to sixth magnitude, that is, to the limit of visibility. What increase in optical depth would be necessary to reduce a second, third, fourth, and fifth magnitude star to a sixth magnitude? This may be simply calculated from (1), and $I_2/I_1 = 10^{-0.4(m_2-m_1)}$. The intensity ratio I_6/I_m between a sixth magnitude star and one of another magnitude, m, is simply given by $10^{-0.4(6-m)}$. Since that ratio represents the increase in optical depth necessary to extinguish the starlight of that magnitude, it follows that the value of $e^{-KL \sec\theta}$ that equals that ratio is the value for extinction.

Thus, by taking the log of I_6/I_m[i.e., the log of $10^{-0.4(6-m)}$] the value of $KL \sec\theta$ for extinction can be determined and from this value of θ. As discussed above, relative to today, 0.266 must be subtracted from the optical depth value to determine the actual optical depth increase over today's values for total eclipse.

The angle (90° − θ) is the angle above the horizon at which stars of the 1, 2, 3, 4, 5 magnitudes, respectively, will first come into view. The angles above the horizon and the magnitudes of stars that will be visible at those angles are shown in Figure 3.

It is evident that even though each magnitude of star is distributed uniformly throughout the heavens, as for the antediluvian sky, only in a fraction of it would stars of a given magnitude be seen. That fraction depends on the maximum zenith angle for visibility: the angle called $\theta_{ext}/2$). Thus under the canopy, for instance, the fraction of the sky in which third magnitude stars might have been seen was $2\sin^2(76°/2)$ = 0.74 about.

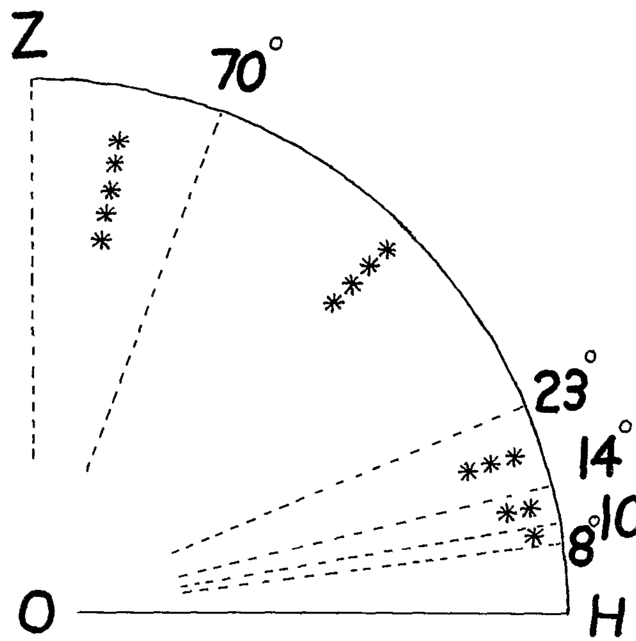

Figure 3. This shows the magnitudes of stars which would have been visible at various angles above the horizon, under the canopy. O is the point of observation, OH the horizontal, Z the zenith. The number of asterisks in an interval shows the number of magnitudes visible in that interval. Between 8 and 10 degrees, for instance, only the first magnitude would have been visible. Between 10 and 14 degrees the first and second would have been visible. Etc.

The ration of the fraction A_p which applies today is equal to the ratio of $2\sin^2(\theta_{ext}/2)$ to the same expression as it applies to conditions today. The angles involved are given in Table 4. Thus, for the first magnitude, the ratio is given by $A_c/A_p = [\sin^2(82°/2)]/[\sin^2(86°/2)]$ = 0.91. I.e., 91% of the antediluvian sky was available for stars of first magnitude. See Figure 3 for an illustration.

An analogous calculation gives the fractions applicable to the other magnitudes; some results are shown in Table 5. Thus, while 743 stars were potentially visible to Adam,[39] only a fraction of that number were visible at any one time.

When Adam looked up into the antediluvian heavens, if there were 40 feet of precipitable water in the vapor canopy, he saw about 255 stars on a clear night when the moon was dark. If the moon was full, the fifth magnitude stars would have been obscured and he would have seen only about 210 stars.[40] Thus, when the canopy condensed and Noah left the ark, he would have seen 2500 − 255 = 2245 new stars (assuming clear night and no moon).[41] (The twenty-seventh of a lunar month would be nearly the dark of the moon. Genesis 8:14.)

Effect of Attenuation on Sunlight

What about the sun? Because of its enormous intensity, and the logarithmic response of the eye, sunlight would not be attenuated enough for one to notice a great difference in intensity. However, the sun would have been somewhat redder in color due to the Rayleigh scattering of the blue light (much more of the red light relative to blue would "get through"). The sight of a suddenly distinct and bright yellow orb for a sun on the post-flood earth could have been quite a striking change

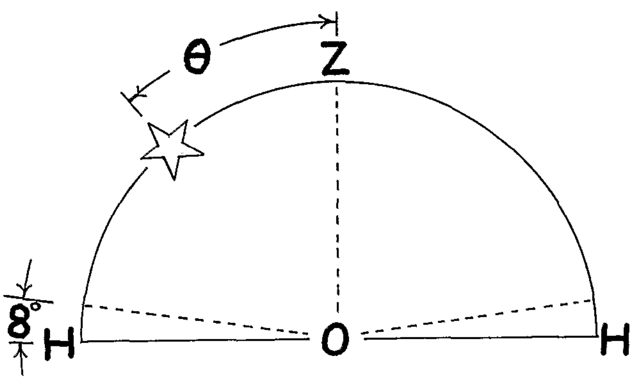

Figure 4. This indicates the part of the sky in which some stars would have been visible under the canopy. Some, as is shown in the text, would be visible at any angle above the horizon greater than 8 degrees. Here O indicates the point of observation, HOH the horizontal, and Z the zenith. The height of a star may be stated in terms of its zenith angle θ, as shown.

Table 5. This shows the number of stars of the first five magnitudes, and the number of them, 34%, which would have been potentially visible to Adam, under the canopy. The fourth column shows the number of those which would be high enough in the sky at a given time to be seen; and the numbers are found by multiplying those in the third by the ratio of $\sin^2(\theta_{ext}/2)$ before the flood to the same expression after the flood. The angles are given in the fifth and sixth columns of Table 4. Thus for the first magnitude the ratio is 0.91, as already calculated. See also Reference 42.

Magnitude	*Number of Stars*	*Number Potentially Visible to Adam*	*Number Actually Visible Under the Canopy*
1	20	7	6
2	65	22	20
3	200	68	59
4	500	170	125
5	1400	476	46
Totals	2185	743	256

for Shem, Ham, and Japheth to relate to their descendants. The pre-flood sun was only 77% as "bright" as today's sun. Even today at sunset, a bright red sun is often observed. This would have been quite pronounced under the canopy.

Astrology, Sun-Worship, and the Collapse of the Canopy

Surely the condensation of the ancient vapor canopy would have left a marked impression on the minds of Noah and his sons and their wives as they described the appearance of the pre-flood heavens in comparison with the heavens after the Deluge. The sigh of an additional 2245 stars, a 23% increase in the intensity of sunlight (noticeable, if not striking, anywhere, and even more marked at the horizon), and of the yellow orb in contrast to the reddish disc of the pre-flood sky could have provided fertile soil for the development of some pagan ideas. In particular, the pagan religions ascribed to the stars and the sun a personal nature and hence could have seen in these accounts passed on down from the sons of Noah, a reference to a battle among the gods.

Sun-Worship in the Ancient Near East

A common thread in most of the myths of the ancient Near East is that of worship of the sun. In many of these myths, the worship of the sun was preceded by the worship of the sky god, the water heaven or an inferior sun. Often in the myths, the present sun has replaced a former sun.

The entirety of Egypt's religion revolved around the worship of Ammon-Re, the sun god. In Greece, the former sun, Hyperion, is replaced after the banishment of the water heaven by the present sun, Helios. Helios supposedly was drowned in the ocean and then raised as the luminous sun.[43]

A similar theme is echoed in Iranian religion where the sun who reigned during the rule of the water heaven, was Ahura-Mazda. With the banishment of Varuna (the water heaven), a new sun, Mithras, took over after conquering the darkness.[44] Again, the theme of a new sun could reflect the physical fact of the change in the appearance and intensity of the old sun, due to the attenuation of sunlight under the canopy.

In Mesopotamia, Marduk, the original sun god, is taken over by Shamash, the new sun god.[45]

It is curious, that in most of the myths, it is the sky god (cf. Ouranos of the Greeks) who is original and the sun god comes along later, as the central deity. As Ferguson has observed, "The sun gives light and life. But it is the sky-god, not the sun-god, who predominates in early religion."[46] In Egypt, Ammon-Re began to absorb the other gods by the fifth dynasty. In Persia, Ahura-Mazda (the old sun) is viewed as the sky god and is supreme over the sun.[47]

In this connection, Velikovsky has noted a peculiar theme in many ancient myths: the sun ages.[48] It is quite common to find a reference in the myths to a new sun in the sky at the beginning of every new age. The Mayas, for example, numbered their ages by giving them the names of the consecutive suns. Interestingly enough, the first sun was the "Water Sun." It was followed by several eras, each marked by a new sun (Earthquake Sun, Hurricane Sun, and Fire Sun) to which various catastrophes are attributed.

Ixtililxochitl (circa 1568-1648), an author who described Indians of Mexico, called the world ages by the names of suns. Again, the "Water Sun" was the first age which was ended by the Deluge.[50] Successive ages followed.

The idea of a series of sun ages is found in other Mexican writings. Symbols of the successive suns, for instance, are painted on the pre-Columbian literary documents of Mexico.[51]

The buddhist sacred book of *Visuddhi-Magga* has a chapter on "World Cycles."[52] Three destructions of the world are discussed, one by water, fire and wind. Apparently, after the Deluge, a "second sun" appeared. In the future, more suns will appear. The seventh sun's arrival will result in the whole world bursting into flames.[53]

The Aborigines of British North Borneo, even today, believe that the sky was originally low, and that six suns perished, and at present the world is illuminated by the seventh sun.[54]

Why is it that in so many of the ancient traditions, the word "sun" is substituted for the word "epoch"? Velikovsky asks,

> Did the reason for the substitution of the word "sun" for "epoch" by the peoples of both

hemispheres lie in the changed appearance of the luminary . . . ?[55]

Velikovsky, of course, cites these legends to substantiate a different thesis from that of the collapse of a pre-flood vapor canopy. However, just such a "banishment" of the "water heaven" would precipitate the described visual phenomena. This would explain the sudden burst of sun worship found all over the ancient Near East not long after the time (on Biblical reckoning) that Noah got out of the ark. Within 150 years of that time, the entire human race was immersed in idolatry once again (cf. the Tower of Babel); and thus it is not surprising that the pattern described in Romans 1 would have led to worship of the sun. Given the supposed "personal" nature of the sun, it would have been natural for them to have viewed "him" as a victor in a celestial battle.

The Worship of the Stars

It is of interest that the ancient Near East was involved not only in sun worship, but also star worship, or astrology. This form of idolatry has frequently been associated with the ziggurats, or "temple towers" constructed in and around the ancient city of Babylon. The next historical event mentioned in Genesis after the flood was the incident at Babel (ancient Babylon). While the essence of that rebellion was clearly the pride of man and his desire to be independent of the Creator, Its association with the ziggurat (Tower of Babel) suggests that astrology may have been the particular form of idolatry that was judged, at least in part.

There seems to be general agreement that the actual remains of the biblical Tower of Babel have been uncovered. The Tower was located in a temple complex known as E-sag-ila, "The housewhose head is raised up." alongside of many shrines of the gods, the ancient Tower of Babel pointed toward the heavens. It was called E-temen-an-ki, or "The house of the foundation of heaven and earth."[56] This house had seven stories, and the top story was the residence of the god, Marduk. Cassuto says,

> There can be no doubt that the Biblical story refers specifically to the city of Babylon and the ziggurat Etemenanki therein . . . .[57]

This ninety-foot tower, the house of Marduk, was a center for astrological worship. The Babylonians conceptualized the gods as stars and constellations.[58] The erection of the Tower of Babel is specifically referred to in the *Enuma Elish.*

> They raised up the head of Esagila on high level with the Apsu.
> After they had built the lofty stagetower of the Apsu.
> They established an abode for Marduk, Enlil, and Ea.[59]

The above reports the building of the temple tower made in celestial Babylon. Marduk then builds one for himself on earth below that is patterned after the heavenly model.

> A likeness of what he made in heaven
> Let him make on earth.[60]

The stars had great significance to the astrologically minded Babylonians. Their connection with the Zodiac and with Marduk was well known.

> He created stations for the great gods;
> The stars their likenesses, the signs of the zodiac he set up.[61]

Here's Marduk's creation of the pathways of the gods (the stations or points of the zodiac) is described. It was Marduk who established the Zodiac. The "likenesses" of the gods are the constellations, the signs of the zodiac. From this it may be concluded that in the temple of Marduk, E-temen-an-ki (the Biblical Tower of Babel) the zodiac and star worship had a prominent place.

The primary purpose of the Tower seems to be a house for the god. By using the stairway, the deity could descend to the lower level of men. By housing Marduk there in Babylon, communication between heaven and earth was assured,[62] i.e., between the gods (stars) and men. In fact, at Larsor, the tower there is even named, "House of the link between heaven and earth."[63] While it is debatable that the purpose of the Tower was related to observation of heavenly bodies,[64] there is some evidence that this may have been a secondary function.[65]

It is clear, then that the Biblical Tower of Babel served as a center for astrology and star worship. It was in that Tower that post-flood man's prideful rejection of the true God was epitomized in his unity around the worship of the stars instead of fear of the Lord.

Why was it that within 150 years of the flood the worship of the stars had already become, virtually, a one-world religion? Saggs suggests,

> There is the theoretical consideration that the idea can only have arisen in a milieu where celestial bodies were regarded as divinities affecting the life of mankind . . . .[66]

Much of the religion of the ancient Near East was devoted to getting the stars, the moon, and the sun, on the side of the worshipper by means of magic. They concluded that the stars affect conditions on earth. Why did they draw this conclusion? Could it be that after the greatest flood and cataclysmic destruction that mankind ever knew, over 2000 new stars appeared in the heavens? Like the victorious sun, the stars (i.e., the present gods) were victorious over the forces of chaos and restored order to a shattered planet, so people reasoned. Surely, they must control the destinies of men!

Whether or not this explains the origin of astrology is, of course, debatable. What is clear, however, is that the first recorded general event after the flood in the Bible is the rebellion at the Tower of Babel. There is no mention of astrology or sun worship prior to the flood. Yet suddenly, men are worshiping the stars. Why? The changed appearance of the post-diluvian heavens may suggest the answer.

The Apostle Paul clearly explained how the true story related by the sons of Noah became perverted into the worship of idols, or the stars.

> For even though they knew God, they did not honor Him as God, or give thanks; . . . . (Romans 1:21)

In other words, mankind after the flood knew all about the true God. From Noah's sons they learned that the Deluge had been an act of judgement.

> . . . but they became futile in their speculations, and their foolish heart was darkened. Professing to be wise, they became fools and exchanged the glory of the incorruptible God for an image in the form of corruptible man, and of birds and four-footed animals and crawling creatures (Rom. 1:21-23).

Instead of seeing the Deluge as an evident warning that God deals with justice in the affairs of men, professing themselves to be wise, they concluded that the post-flood appearance of the stars (which they took to be victorious gods) demonstrated that the stars rule the earth and not Yahweh of the Hebrews. Thus, they worshipped "images", which may originally have been not statues but Orion, the Great Bear, Pegasus, Aquarius, Virgo, Leo, and other constellations which were in the likeness of their gods.

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[13]Computing from (1) gives an exact result of 4.875×10^{10} times brighter.

[14]Shortley and Williams, *op. cit.*, vol. 2 p. 504.

[15]See the Handbook of Chemistry and Physics, 56th edition, 1975-1976, p. E-205. Since the figures are approximate, the ratios of luminances will not always agree exactly with the visual magnitudes.

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[34]See the discussion under "Visibility at Various Zenith Angles".

[35]The optical depth of the canopy for total extinction would be given by the calculated total depth for total extinction minus the optical depth of the present atmosphere with allowance for aerosols. The figures are : $4.605 - (0.346+0.115) = 4.144$. From (5), $\omega = KL/1.269 \times 10^{-4} = 4.144/1.269 \times 10^{-4} = 32{,}656$ cm = 1.071 feet. This refers to zero zenith angle.

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[37]Olcott and Putnam, *op. cit.* p. 498.

[38]The 0.266 is the difference between KL_c and KL_p, *viz.* $0.616 - 0.350 = 0.266$.

[39]See the discussion under "Visibility at Various Zenith Angles".

[40]While 255 stars were potentially visible at one time under the canopy, here the 46 fifth magnitude ones are eliminated, leaving 209, or say 210.

[41]See the discussion under "Visibility in the Pre-Flood Heavens".

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