following five questions would substantially clarify the issue:

a. How can a chronology be constructed with a high percentage of complacent specimens?

b. How can specimens with up to 10 percent of their rings missing be cross matched under any circumstances?

c. How can this chronology be used to "calibrate" radiocarbon dating when radiocarbon dating is used in construction of the chronology?

d. If a ring is missing how can it be found, especially when a high percentage of rings are missing?

e. Why is only the final chronology published, with refusal to release the data upon which it is based?

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A CRITIQUE AND MODIFICATION OF VELIKOVSKY'S CATASTROPHIC THEORY OF THE SOLAR SYSTEM

J. C. KEISTER*

Velikovsky's catastrophic theory of the Solar System is briefly reviewed. One of the most serious physical problems of his theory (i.e., that of determining a mechanism for disposing of tremendous orbital energies) is discussed. Specifically, gravitational interaction, electrical interaction and magnetic interaction are each considered, and found to be inadequate to dispose of the required amount of orbital energy.

A modification to Velikovsky's theory is then proposed, which would permit gravitational interaction (electrical and magnetic interactions are still far too weak) to dispose of a far less amount of orbital energy, and still fulfill the **appearance** *of what Velikovsky's theory proposes.*

Some theological aspects of Velikovsky's theory are discussed and it is pointed out that whenever the theory and Scripture truly disagree, the theory obviously must be modified. Analyses of such a theory are worthwhile means for developing analytical tools for handling other catastrophic theories.

Background

Velikovsky's theory of the Solar System (which is discussed in his book *Worlds in Collision*) centers around the catastrophes related to the Exodus, the Battle of Jericho, the battle at Beth-Horon, and the seige of Jerusalem by Sennacherib. A brief summary of the theory (described more extensively in *Penseé*)[1] is as follows:

1. Some time before 1500 B. C., Venus was expelled from Jupiter.

2. Venus passed close to the Earth during the time of the Exodus. When Venus first approached the Earth, the fine red dust in its cometary tail gave a bloody hue to the land and sea, which Velikovsky used to "explain" water being turned into blood as the first of the plagues in Egypt. Velikovsky uses other similar phenomena to "explain" the other plagues and happenings of the Exodus.

3. Venus then retreated from the Earth and completed an orbit. About forty years later, when Joshua attacked Jericho, or a little later, at the battle of Beth-Horon, Venus approached again. Great stones were cast on the Earth and the Sun stood still as was recorded in Joshua 10:11. According to Velikovsky, men worshipped Venus to a far greater extent thereafter than they did before these catastrophes took place. For centuries, there was the menace to these people of the close passage of Venus to the Earth.

4. Venus then took an irregular path, and had a near-collision with Mars in the days of Uzziah, king of Jerusalem. Prophesies in Amos are then quoted by Velikovsky as predictions of dire consequences from the close passage of Mars. The first passage of Mars is associated datewise with the founding of Rome in 747 or 753 B. C. A new calendar was formed. Mars and Venus then competed for the allegiance of men. Prophets (Joel, for example) spoke of evil consequences to come.

5. In or about 687 B. C., Mars made a close pass to Earth, and a giant thunderbolt charred the bodies of the army of Sennacherib. The Sun retreated several degrees due to the change in the rotation in the Earth.

6. Finally, after many passes of Venus and Mars, and of Mars and Earth, Venus emerged a tame planet as Velikovsky asserts is the meaning of Isaiah 14:12-17.

A brief summary: Venus was expelled from Jupiter about 1500 B. C. Venus had near-collisions with the Earth and continued to make near-passes until about the 8th century B. C. when it nearly collided with Mars. A period of time lapsed when encounters of the Earth and Mars and of Venus and Mars were observed. Mars then had its final encounter with Venus, stabilizing the orbit of Venus.

Because of the success of predictions based on Velikovsky's theory, (which are outlined in detail in *Penseé*[2]) this theory warrants a serious examination from the physical, historical and Biblical viewpoints. In the present article the physical problems associated with the planetary orbital energy changes are examined. Examination of the physics of the expulsion of Venus from Jupiter (the largest and most severe energy problem) is being considered by the author in a separate study.

The orbital energy problem is basically one of disposing of enough kinetic energy to bring Venus down from its expulsion orbit to its present orbit. In the three sections that follow, the mechanisms of gravitation, electrostatic interaction, and magnetic interaction are respectively considered as means for permitting the various planets (i.e., Mars, Earth and Jupiter) to dispose of the required amount of kinetic energy for Venus.

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Gravitational Attraction

The gravitational interactions between Venus and Mars, Venus and Earth, and Venus and Jupiter are all considered as means for extracting orbital energy from Venus. In view of the fact that Venus interacted with Mars last, and also because the Venus-Mars interaction is the most *inefficient* for extracting energy, we shall consider the maximum amount of energy that can be extracted by Earth and Jupiter first, and then determine whether Mars could in fact extract the rest of Venus's orbital energy.

First, an estimate is needed of the total amount of energy that needs to be extracted. Assuming that Venus' initial orbit has a seven year period,[3] it can be shown (see Appendix I) that the major eliptical length of the orbit of Venus is 1.40 R_j, where R_j is the distance of Jupiter to the Sun.

The final orbit of Venus is only 1/7.2 of the distance from the Sun at which Jupiter is.[4] The major axis of Venus' final orbit is the diameter of the very nearly circular orbit Venus travels today, which is (2/7.2) R_j. The energy E that must be lost by Venus is given by:

$$E = GMM_s(7.2/2R_j - 1/1.40R_j) = 2.9GMM_s/R_j \quad (1)$$

where M is the mass of Venus, M_s that of the Sun, and G is the universal constant of gravitation.

Now, Jupiter could in principle change the orbit of Venus into a *very* elongated ellipse, so that one tip extends to the Sun, while the other tip extends to Jupiter's orbit. The major diameter in this case would be simply R_j, and the energy of this orbit $GMM_s(1/R_j)$. The difference in energy per encounter between this elongated orbit assumed to have been established in one encounter and the original orbit is:

$$\Delta E_j = GMM_s(1/R_j - 1/1.40R_j) = 0.29GMM_s/R_j \quad (2)$$

which is equal to only 10% of the total change of energy, E. Therefore, Jupiter can extract at most 10% of the required total energy loss, E.

Consider next the amount of energy which the Earth could extract from Venus. In principle, the Earth could extract a great deal of energy from Venus, but this would mean that the Earth would have to have been much closer to the Sun than it now is. Now, the radiant energy per unit area impinging on any object is inversely proportional to the square of the distance of that object from the radiant energy source.

So, if the Earth were at a distance of $2^{-1/2}R_e$ (where R_e is the present Earth orbit distance from the Sun), it would receive *twice* the radiant energy it is now receiving from the Sun. Furthermore, it would seem *highly* unlikely that the Earth's orbit could be changed so drastically and yet have it end up so nearly circular today. Also, the effect of having *twice* the sunlight on the Earth (if we assumed a gray or black body radiation loss) would be to raise the absolute temperature T in accordance with the T^4 rule.

The Earth's average equivalent radiation temperature is of the order of 270°K, and if the energy received from the Sun is doubled, then T^4 is also doubled (assuming internal core heat loss is relatively negligible). This would produce a temperature of $2^{1/4} \times 270 \approx 1.19 \times 170 = 320$°K which corresponds to an average Earth temperature of 120°F (which is *way* too hot!).

Even if the Earth core energy loss were, say, half the average heat loss (which would then put the Earth's average radiation temperature at about 75°F), the sun's radiant energy would produce extraordinarily high temperatures for living purposes.[5] Be that as it may, we will suppose that the Earth was originally at a distance of $2^{-1/2}R_e$ even though recognizing that it is *unlikely* the Earth could have been in that close to the Sun and have absorbed so much of Venus's orbital energy. So a *maximum* energy the Earth could absorb would be (the Δ again indicating the change per encounter):

$$\Delta E_e = GM_sM_e(2^{1/2}/2R_e - 1/2R_e) \quad (3)$$

where Me is the mass of the Earth, and Re is the distance of the Earth from the Sun.

Since $M_e = 1.25M$, and $R_e = R_j/5.2$, about, this comes to be about $1.35GM_sM/R_j$ which is around 50% of the total energy loss required.

Therefore, Earth and Jupiter together can dispose of *at most* 60% of the total orbital energy loss of Venus. Interactions between Venus and Mars *must* dispose of the other 40%.

Optimum conditions of interactions between Venus and Mars are now assumed, whereby the planets come within Roche's distance from each other, so as to promote the maximum exchange of energy. A formula is derived for the maximum deflection angle corresponding to this "brush pass" in Appendix II. This deflection angle then is used to derive the optimum orbit interaction angle between Venus and Mars which will maximize the energy exchange between the two planets.

The calculation for the optimum orbit intersection angle is performed in Appendix III. The results show that at *most* less than 5% of the total orbital energy loss can be affected with each near-collision of Venus with Mars.

Therefore, it would take over *8* such optimum near-collisions between Venus and Mars to dispose of the required 40% of the total orbital energy loss. Such a situation would be *most* unlikely. Furthermore, Velikovsky's theory requires substantial energy losses with only *two* such major passes. Therefore, the mechanisms of electrostatics and magnetism are next investigated to see if these might somehow enable Mars to extract enough orbital energy from Venus.

Electrostatic Interaction

The problem here is to determine whether electrical charges could have been built up on Venus and Mars to such an extent that the electrostatic force would dominate the gravitational attraction. If so, then some sort of repulsion between the two planets might have permitted a billiard-ball type of interaction, and the planets would not need actually to have touched.

Since the charge would be associated with material on the surface of the planets, the electrical forces would tend to lift that material off the planets. The criterion used here to set an upper limit on the electric field near the surface will be this: that the electrical force on material at the surface should be no greater than the force necessary to break the material. For if it were greater, material would break loose and fly off (the electrical force would be much greater than that of gravity). Since the material would carry charge with it, the planet would be discharged rather rapidly.

The breaking strength of granite, limestone, and other common rocks is somewhat less than 100,000 p.s.i. Suppose, then, that the electrical force were of this magnitude, which, in other units, is 6.9×10^9 dynes/cm^2. Moreover, this force is given by the product of the strength of the electric field and the surface density of charge, in units of charge per square cm. (the c.g.s. electrostatic system of electrical units is being used here.)

Now, if there is a charge Q on a sphere of radius r, the field at the surface is of magnitude Q/r^2, and the surface density of charge is $Q/4\pi r^2$. Thus the criterion comes to be

$$\frac{Q^2}{4\pi r^2} = 6 \cdot 9 \times 10^9 \qquad (4)$$

Now for Venus, $r = 6.31 \times 10^8$ cm, and for Mars 3.42×10^8. The Q's calculated by the above formula are Q_m (Mars' change) = 3.44×10^{22} esu. The electrostatic force between these two charges is given by the product divided by the square of the separation. Thus the force between Mars and Venus at any separation (i.e., distance between centers) would be, in dynes, 4.03×10^{45} divided by the square of the separation. (This assumes that the charge remains uniformly distributed. Actually, when the planets were very close the electrostatic force would be somewhat less, because charge would be partly repelled to the most distant parts of the planets.)

The gravitational force would be given by the product of the masses, about 4.80×10^{27} gms for Venus and 6.40×10^{26} for Mars, and the universal constant of gravitation, 6.67×10^{-8}, divided by the square of the separation. So the gravitational force would be about 2.05×10^{47} divided by the square of the separation.

So the electrostatic force, even according to the extreme assumptions made here, would be only about one fiftieth of the force of gravitation. Thus the electrostatic force could have little effect on the orbits.

Magnetic Interaction

The possibility that magnetic forces between the planets might have been effective in re-arranging their orbits will be discussed at greater length in Appendix IV. It is enough to note here that it turns out that the magnetic forces are no more able to accomplish what is asked of them than the electrostatic ones are.

Modifications to Velikovsky's Theory

In view of the above, it appears as though there is no known mechanism, gravitational, electrical, and magnetic forces having been ruled out, that would be sufficient to dispose of the excess orbital energy of Venus. Therefore, it seems very doubtful that Venus could have done what Velikovsky's theory insists that it must have done to effect the catastrophic events specified.

Nevertheless, it is possible to modify the theory such that everything *appears* in a manner suggestive of the theory, without actually having Venus be the "actor". Specifically, suppose that *Mars* was the actor, all the time.[6] Consider the following scenerio, matched to Velikovsky's original theory:

Velikovsky's Theory	Modified Theory
1. Venus comes from Jupiter, and looks like a comet.	1. *Mars* comes from Jupiter, (or appears to) and looks like a comet.
2. *Venus* has near-collision with the Earth.	2. *Mars* has near-collision with the Earth.
3. Venus has a near-collision with Mars, (which is approximately located at Venus' *present* orbit) and sends Mars out into an eccentric orbit.	3. Mars has a near-collision with Venus, (which is located at the same orbit as it is at present), and then continues its way in a modified orbit. Mars has collisions with asteroids, loses most of its tail and picks up two trebants and looks like a different planet. In fact it looks like Mars at present.
4. Mars has a near-collision with the Earth.	4. Mars has a near-collision with the Earth.
5. Mars has final near-collision with Venus.	5. Mars has final near-collision with Venus.
6. No explanation for how Mars gets to its present orbit.	6. Mars has a collision (perhaps several) with more asteroids, and then settles into its final, present orbit.

Mars as the Actor

A relatively simple calculation reveals that Mars would need to lose only 1/20 the energy which Venus would need to lose. This means that, in principle, Mars could lose up to all the required energy in a single near collision with, say, Venus or Earth. Therefore, one of the biggest problems of Velikovsky's theory, that of excess orbital energy, would be disposed of. And there is more: the final orbit of Mars is somewhat eccentric, whereas the orbit of Venus is very nearly circular. It seems unlikely that Venus, starting from a very eccentric orbit, would eventually have a very nearly circular one.

Furthermore, why would Venus not have picked up a trebant or two while orbiting near Jupiter and the asteroids? Apparently Mars did pick up trebants; and Mars has less capture ability than Venus, being much lighter.

Obviously, there may be difficulties with the new model. For instance, how does one dispose of the tail of a comet? It must have been disposed of; Mars today has little atmosphere. This is indeed a difficult problem, although possibly a close pass by the Sun (assuming a very eccentric orbit for Mars) could have blown most of the atmosphere away. Nevertheless, a problem of this sort is (energetically speaking) far easier to solve than the orbital energy problem that Venus poses.

Conclusions

1. I do not mean to deny the possibility of catastrophic planetary interaction; but the only way that the basic thrust of Velikovsky's theory can be maintained is by changing the notion that *Venus* was the main actor. Modification of his theory so that *Mars* is the chief actor will at least permit the theory to be feasible from the energy standpoint.[7]

2. Acceptance of Velikovsky's theory (or a modified version), does *not* mean rejecting scripture, *provided*: (a) all parts of his theory which go contrary to scripture are modified to be consistant with scripture, and (b) we recognize that God governs *all* of the universe, and that so-called "natural" events are every bit as much God's doing as the miraculous events. Therefore, to "explain" some event that took place by "natural" means does not in any way leave God out of the picture.

3. Thinking and speculating along the lines of possible catastrophes, may lead to lines of thought which correspond to the actual historical chain of events which took place. Whatever else has happened, Velikovsky has introduced a mode of thinking (interdisciplinary in nature) which may be invaluable in attempting to understand the universe around us. If Velikovsky is, say, only 20-30% correct in his theory, he will have performed far better than many steady state, uniformitarian type astronomers.

4. It should not be assumed that the Creation Research Society, or individual members of the Society, or even the author, necessarily believe that the events outlined in this modified theory actually happened. The point being made is that some such modification is necessary if the theory is to be even a plausible one.

Acknowledgements

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Appendix I

Calculation of the Major Axis of Expulsion Orbit of Venus

By ordinary mechanics,[8] the Period T of the planet around the Sun is given by

$$T = \frac{2\pi a^{3/2}}{(GM_s)^{1/2}} \tag{5}$$

Equation 5 is an approximation, good only if the planet mass is negligible compared to the Sun.

Here a is a semi-major axis (i.e., half the tip-to-tip dimension) of the orbit; the other symbols have been defined already.

Now as given in e.g. the Handbook of Chemistry and Physics, $M = 4.8 \times 10^{27}$, and $M_S = 1.97 \times 10^{33}$ gm. Also, Equation 5 may be put into a form to given the semi-major axis directly:

$$a = \left(\frac{T}{2\pi}\right)^{2/3} (GM_s)^{-1/3} \tag{6}$$

When the proposed seven year orbit (in appropriate units) is put in for T, along with the other numbers, the result is $a = 5.43 \times 10^{13}$ cm. Hence the length of the orbit is 1.09×10^{14} cm. That number is about $1.40R_j$, since $R_j = 7.78 \times 10^{13}$ cm.

Appendix II

The Maximum Angle of Deflection for Encounter of Venus with Mars

The purpose is to develop a formula relating the maximum scattering angle θ to r_{min} (the distance of closest approach from Mars to the center of mass). Consider Figure 1, in which b is what is called the impact parameter, and θ the angle of scattering relative to the center-of-mass coordinate system. Locations of Mars, the center of mass between Mars and Venus, and Venus are represented, respectively by M, C and V. Incidentally, while that system is picked here, later the scattering problem will have to be related to a co-ordinate system in which the Sun is at rest.

Suppose that Mars has an initial velocity V_{mo} relative to the center of mass, the impact parameter being b, as mentioned. Then the angular momentum of Mars is mbV_{mo}. The total energy of Mars, relative to the center of mass, is $(m/2)(V_{mo})^2$. By conservation of evergy and of momentum, one can write

$$\frac{m}{2}V_m^2 - \frac{GMm}{r}\tau^2 = \frac{m}{2}V_{mo}^2 \tag{7}$$

Here m and M are the masses and subscript indices of Mars and Venus, respectively, V_m and V_M are velocities relative to the center of mass, V is the velocity of the center of mass, subscript zero indicates initial values, r is the distance from Mars to the center of mass, and $\tau = M/(M+m)$.

When V_m is expressed in polar coordinates, the dot here, as elsewhere, indicating differentiation with respect to time, one gets

$$\frac{m}{2}[\dot{r}^2 + r^2\omega^2] - \frac{GmM}{r}\tau^2 = \frac{m}{2}V_{mo}^2 \tag{8}$$

Where ω indicates the angular velocity of Mars around the center of mass. The angular momentum of Mars, relative to the center of mass, is

$$m\omega r^2 = mbV_{mo} \tag{9}$$

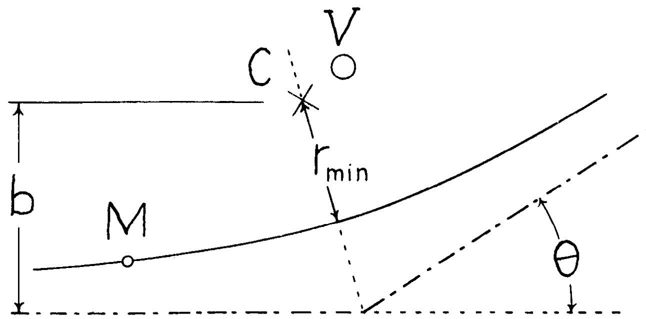

Figure 1. The path of Mars as (according to the proposal investigated here) it passed close to Venus. The path is a hyperbola; it is enough to find the angle between the asymptotes, the straight lines which the hyperbola approaches. *M* indicates Mars, *V* Venus; and *C* is the center of mass of the system. *b* is the impact parameter, the perpendicular distance from the asymptote of the original orbit to the center of mass. r_{min} is the minimum distance from the center, and θ the angle through which the planet is deflected.

Consequently, Equation 8 can be written as

$$\dot{r}^2 + \frac{b^2V_{mo}^2}{r^2} - \frac{2GM}{r}\tau^2 = V_{mo}^2 \tag{10}$$

Since when $r = r_{min}$, $\dot{r}^2 = 0$, it follows that

$$V_{mo}^2 r_{min}^2 + 2GMr_{min}\tau^2 - b^2V_{mo}^2 = 0 \tag{11}$$

This is solved for r_{min} to give

$$r_{min} = [-2GM\tau^2 \pm (4G^2M^2\tau^4 + 4b^2V_{mo}^4)^{1/2}]/2V_{mo} \tag{12}$$

The negative root cannot apply, so the solution is

$$r_{min} = [(4G^2M^2\tau^4 + 4b^2V_{mo}^4)^{1/2} - 2GM\tau^2]/2V_{mo} \tag{13}$$

Now, the relation between b and θ, the scattering angle, must be determined. The relationship is established by considering the change in momentum from the initial to the final state, with the help of reference 9. The result, when corrected for center-of-mass coordinates, is

$$b = \frac{GM\tau^2 \cot(\theta/2)}{V_{mo}^2} \tag{14}$$

Now substitute Equation 14 into Equation 13 to obtain

$$r_{min} = \frac{GM\tau^2}{V_{mo}^2}\left(\csc\frac{\theta}{2} - 1\right) \tag{15}$$

Now the distance between the centers of the two planets must be at least $2.5r_v$, corresponding to Roche's limit from Venus, r_v being the radius of Venus. Therefore, since $r_{min} = \tau \times$ (distance between centers of planets), one obtains

$$r_{min} > 2 \cdot 5\tau r_v \tag{16}$$

By use of Equation 15, Equation 16 becomes

$$\csc\frac{\theta}{2} > 1 + \frac{2 \cdot 5mV_{mo}^2}{(GMm\tau/r_v)} \tag{17}$$

Since M is about $7m$, τ is about 7/8. Also, $(m/2)(V_{mo}^2)$ can be related to a fraction f of the potential energy, as follows:

$$\frac{m}{2}V_{mo}^2 = \frac{fGM_s m}{R_v} \tag{18}$$

Here M_S is the mass of the Sun, and R_V is the distance of the Sun from Venus today (hence, according to Velikovsky's theory, the former distance of Mars from the Sun). Thus Equation 17 can be re-written

$$\csc\frac{\theta}{2} > 1 + \frac{40f}{7}\frac{M_s}{M}\frac{r_v}{R_v} \tag{19}$$

Now in the Handbook of Chemistry and Physics $M_s/M = 329390/0.8073 = 4.03 \times 10^5$; and $r_v/R_v = 3785/67{,}000{,}000 = 5.66 \times 10^{-5}$. Therefore,

$$\csc\frac{\theta}{2} > 1 + 131f \qquad (20)$$

So a formula relating the maximum deflection angle to the fractional energy in the center-of-mass system has been derived. In Appendix III, this formula is used to help derive a maximum of energy which can be extracted from Venus in a given near-collision with Mars.

Appendix III

Calculation of the Maximum Possible Loss of Energy per Near-Collision Between Venus and Mars

The thrust of the calculation here is to determine the optimum orbit intersection angle between Mars and Venus, which will transfer a maximum amount of energy between Venus and Mars, following a near-collision between the two planets. This calculation is concerned with motions of Venus and Mars relative to the *Sun*, as well as to the center of mass between Venus and Mars. The relationships of all these velocities are illustrated in Figure 2.

Where V_m is the velocity of Mars relative to the Sun, V_{mo} is the velocity of Mars relative to the center of mass - (Venus & Mars), V_v is the velocity of Venus relative to the Sun before interaction, V_v' is the velocity of Venus relative to the Sun after intersection, V_{vo} is the velocity of Venus relative to the center of mass - (Venus & Mars), and V is the velocity of the center of mass of Venus & Mars. Also, γ is the orbit intersection angle between Venus and Mars, and θ is the deflection angle (see Appendix II).

Now, for small velocity changes (and they are small) the change in magnitude from V_v to V_v' is approximately as shown in Figure 2. Thus the change is approximately $2V_{vo} \sin(\theta/2) \cos(\pi/2 - \theta/2 - \beta)$. Or

$$\Delta V_v \approx 2V_{vo} \sin\frac{\theta}{2} \sin\left(\frac{\theta}{2} + \beta\right) \qquad (21)$$

The change in energy of Venus is therefore given by

$$\Delta E_v = \tfrac{1}{2}M\left[4V_vV_{vo} \sin\frac{\theta}{2} \sin\left(\frac{\theta}{2} + \beta\right) - 4V_{vo}^2 \sin^2\frac{\theta}{2} \sin^2\left(\frac{\theta}{2} + \beta\right)\right] \qquad (22)$$

The second term is quite small compared with the first, so

$$\Delta E_v \approx 2MV_vV_{vo} \sin\frac{\theta}{2} \sin\left(\frac{\theta}{2} + \beta\right) \qquad (23)$$

Since the mass ratio of Venus to Mars is 7:1 it follows that $V_{mo} = 7V_{vo}$; and so $V_o = V_{mo} + V_{vo} = 8V_{vo}$. Therefore, by the law of sines

$$\Delta E_v \approx \tfrac{1}{4}MV_vV_m \frac{\sin\gamma}{\sin\beta} \sin\frac{\theta}{2} \sin\left(\frac{\theta}{2} + \beta\right) \qquad (24)$$

Again, this is per encounter. Now it is necessary to consider getting the expressions involving $\theta/2$ and β in terms of γ. Recall from Appendix II that $\csc(\theta/2) = 1 + 131f$, (for the maximum angle of deflection). Therefore $\sin(\theta/2) = 1/(1 + 131f)$. Note that f is the ratio of $(m/2)V_{mo}^2$ to the potential energy of Mars at the distance of Venus from the sun. This potential energy is twice the kinetic energy $(m/2)V_m^2$ at the same distance from the Sun, for a circular orbit. Therefore

$$f = \tfrac{1}{2}\frac{(m/2)V_{mo}^2}{(m/2)V_m^2} = \frac{V_{mo}^2}{2V_m^2} \qquad (25)$$

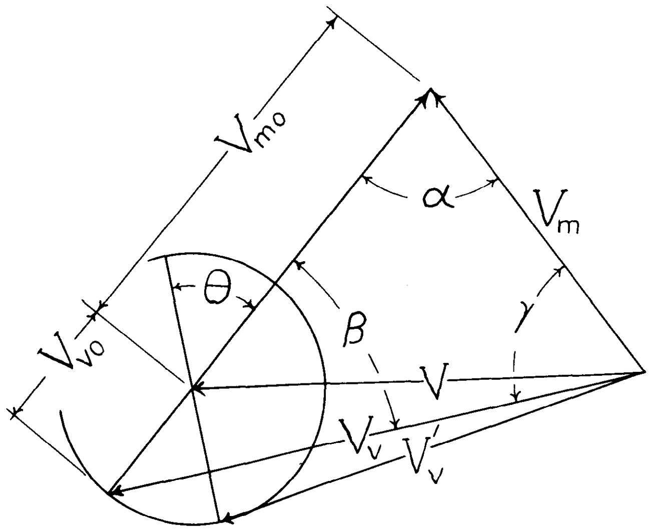

Figure 2. This shows the relations and angles between the various velocities, as discussed in the text. Note that $V_{vo} + V_{mo} = V_o$.

Since $V_{mo} = 7V_o/8$, Equation 25 becomes

$$f = \frac{49}{128}\frac{V_o^2}{V_m^2} = \frac{49}{128}\frac{\sin^2\gamma}{\sin^2\beta} \qquad (26)$$

Now $\sin\beta$ is determined as a function of γ. By the law of cosines, and from Figure 2,

$$\sin^2\beta = \frac{V_m^2 \sin^2\gamma}{V_m^2 + V_v^2 - 2V_mV_v \cos\gamma} \qquad (27)$$

Consequently, Equation 26 for f becomes

$$f = \frac{49}{128}\frac{(V_m^2 + V_v^2 - 2V_mV_v \cos\gamma)\sin^2\gamma}{V_m^2 \sin^2\gamma} \qquad (28)$$

Rewriting the expression for ΔE in Equation 24 gives

$$\Delta E_v = \frac{MV_vV_m}{4}\frac{\sin\beta}{\sin\gamma}\left[\frac{1}{1 + 131f}\right]\left[\frac{\cos\beta}{1 + 131f} + \sin\beta\left(1 - \left(\frac{1}{1 + 131f}\right)^2\right)^{1/2}\right] \qquad (29)$$

By defining $\xi = (V_v^2 + V_m^2 - 2V_vV_m \cos\gamma)/V_m^2$, Equations (27) and (28) which will be used in Equation 29, simplify to the following

$$\sin^2\beta = \frac{\sin^2\gamma}{\xi}$$

$$f = \frac{49\xi}{128} \qquad (30)$$

Therefore, Equation 29 becomes (31)

$$\Delta E_v = \frac{MV_vV_m}{4(1 + 50\xi)^2}\left[(\xi - \sin^2\gamma)^{1/2} + \sin\gamma((1 + 50\xi)^2 - 1)^{1/2}\right]$$

When ρ is set equal to V_v/V_m, Equation 31 becomes

$$\Delta E_v = \frac{\rho MV_m^2}{4(1 + 50\xi)^2}\left[(\xi - \sin^2\gamma)^{1/2} + \sin\gamma((1 + 50\xi)^2 - 1)^{1/2}\right] \qquad (32)$$

It will be recalled from Equation 1 that the kinetic energy of Venus, in its present orbit, is 3.6 GMM_s/R_j, and the total required energy loss E is 2.9 GMM_s/R_j. Now put MV_m^2 in Equation 32 into terms of E, by the following argument. When Mars was in Venus' present orbit, according to Velikovsky's theory, its kinetic energy could be set equal to the total energy (i.e., to its magnitude; the total energy is negative), as is generally true for a circular orbit. Thus, before the encounter, $mV_m^2/2 = 3.6GmM_s/R_j$. Multiply both sides of that equation by M/m. Then $MV_m^2/2 = 3.6GMM_s/R_j$. So $MV_m^2 = (2 \times 3.6)(E/2.9) = 2.5E$. Therefore, Equation 32 can be modified to

$$\frac{\Delta E_V}{E} = \frac{0 \cdot 63\rho}{(1 + 50\xi)^2} [(\xi - \sin^2\gamma)^{1/2} + \sin\gamma((1 + 50\xi)^2 - 1)^{1/2}] \qquad (33)$$

Now, if Mars must dispose of 40% of the excess energy of Venus, then the first near collision of Venus and Mars must have occurred when Venus' kinetic energy was at least $3.6GMM_s/R_j + 0.4 \times 2.9GMM_s/R_j = 4.76GMM_s/R_j$. Since $MV_m^2/2 = 3.6GMM_s/R_j$, the least that V_v^2 could be for the initial collision is

$$V_v^2 = \frac{4 \cdot 76}{3 \cdot 6} V_m^2 = 1 \cdot 32\, V_m^2 \qquad (34)$$

So $\rho_{min} = 1.32^{1/2} \approx 1.15$.

In Table 1 some calculations are shown of the percent change in the energy of Venus after one near collision, for various magnitudes of ρ and γ. Note that these are the maximum possible losses, since losses tend to get smaller as ρ gets larger. As can be seen, the maximum possible loss of energy per near collision by Venus is always less than five percent of the total energy which Venus would need to lose.

TABLE I

ρ \ γ	0°	5°	10°	15°	20°
1.00	0	2.6	4.1	3.7	3.1
1.05	2.6	4.4	4.5	3.8	3.1
1.10	3.1	4.6	4.4	3.7	3.1
1.15	2.4	4.0	3.9	3.4	2.9
1.20	1.7	3.1	3.4	3.1	2.7

This shows the maximum possible percent change in the energy of Venus in one near-collision with Mars, in terms of the orbital intersection angle γ and the ratio ρ, defined in Appendix III, as being less than 5% of the total needed to be lost.

Appendix IV

Magnetic Interaction

Whatever be the finer details, it would seem reasonable to suppose that the planet's magnetism arises from its being magnetized uniformly throughout, both as to magnitude and as to direction.

Each infinitesimal element of the planet, then, could be considered to contain a magnetic dipole, consisting of two magnetic poles (in the sense in which that term is used in physics, not as it is used in geography) of strength $+\mu$ and $-\mu$, a distance l apart in a direction parallel to the magnetic axis of the planet. The magnetic axis is likely not much different from the geographical axis. Note that the question, whether it is possible to obtain magnetic monopoles as actual isolated physical entities, does not affect the present discussion.

The result then is that one may consider the planet as composed of two interpenetrating spheres, one of positive ("north-seeking") "magnetic charge", the other of negative ("south-seeking"), the centers of the two spheres being displaced one from the other by an amount l, as shown[10] in Figure 3.

Consider each of these spheres separately. It is a uniform sphere of magnetic charge. Since the charge acts according to the inverse-square law, the sphere of charge acts, as far as places outside it are concerned, as if the charge were all concentrated at the center of the sphere.

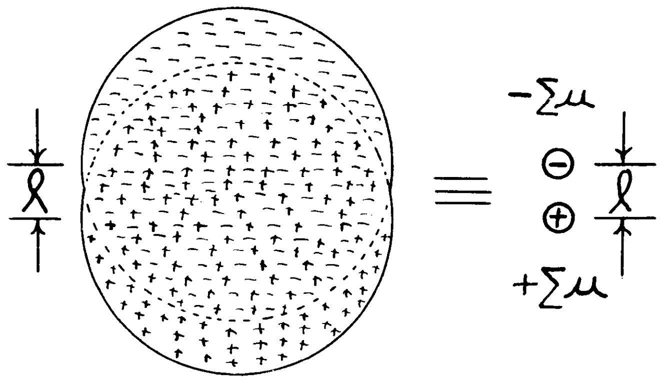

Figure 3. The uniformly magnetized sphere is equivalent to two interpenetrating spheres, one of negative "magnetic charge", the other of positive. These, in turn, as shown, are equivalent to a dipole. The distance *l* is supposed to be infinitesimal in comparison with the size of the spheres. Actually, *l* is not determined separately; only its product with the " charge" matters.

So the two imaginary interpenetrating spheres, and hence the planet itself, act, as to points outside, the same as two magnetic charges, of magnitude $+\Sigma\mu$, the total positive magnetic charge on the planet, and $-\Sigma\mu$, at the center of the planet, a distance l apart. This arrangement is just a magnetic dipole, of moment $l\Sigma\mu$. But the moment of each of the elemental dipoles which make up the magnetization was $l\mu$. Hence the effects, e.g. magnetic field, due to a uniformly magnetized sphere, at points outside the sphere, is the same as that due to a dipole, of moment equal to the total magnetic moment of the sphere, placed at the center of the sphere.

Moreover, two uniform spheres, attracting (or repelling) according to the inverse-square behaviour, affect each other as if they were each one concentrated at its center. Thus the force between two uniformly magnetized spheres is the same as that between two dipoles, of moments equal to the respective moments of the spheres, placed one at the center of each sphere. So all that is necessary is to find the force between two dipoles.

Suppose that the dipoles are lined up end to end, as shown in Figure 4. This would correspond, for instance, to two bar magnets placed end to end. Let the moments be M_1 and M_2 respectively. Note that the l's are supposed to be infinitesimal in comparison with the other dimensions, such as r. Actually, neither l nor μ enter the formulae separately, but only their product, the moment.

The end to end arrangement, as shown, gives the strongest force between dipoles at a given separation. So this assumption is the most favourable possible for the magnetic forces.

Since in the arrangement in Figure 4 both attraction and repulsion are involved, the net force must be found, and it

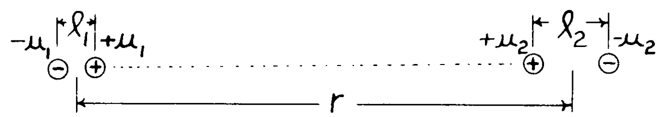

Figure 4. This shows the two dipoles to which the two uniformly magnetized spheres have been shown to be equivalent. The force is then easily calculated. Note that *l* is supposed to be infinitesimal compared with *r*.

comes to be

$$Fm = \mu_1\mu_2 \left[\frac{1}{(r + \frac{l_2 + l_2}{2})^2} + \frac{1}{(r - \frac{l_1 + l_2}{2})^2} - \frac{1}{(r + \frac{l_1 - l_2}{2})^2} - \frac{1}{(r - \frac{l_1 - l_2}{2})^2}\right] \approx \frac{6\mu_1 l_1 \mu_2 l_2}{r^4} = \frac{6M_1M_2}{r^4} \qquad (35)$$

This result comes by expanding and neglecting higher powers of the *l*'s, which have already been assumed to be infinitesimal.

Next, estimate the *M*'s, the moments of the planets.

Suppose that each planet was made of solid iron, and that in each atom of the iron the six outer electrons each contribute three Bohr magnetons of magnetic moment due to orbital motion, and two each due to spin.[11] The magnetic effects of the remaining electrons will pair off, and cancel.

Thus each atom will contribute 30 Bohr magnetons of magnetons of magnetic moment. In one cubic centimetre of iron, of density about 8 and atomic weight 55 there are $(6.025 \times 10^{23} \times 8)/55 = 8.8 \times 10^{22}$ atoms. The number 6.025×10^{23} is Avogadro's number.

So the magnetic moment per c.c. of the iron is, according to this argument, $30 \times 8.8 \times 10^{22}$ Bohr magnetons. Since a Bohr magnet is about 9.27×10^{-21} c.g.s. units of magnetic moment in these units, the magnetic moment per unit volume, or magnetization, of the iron is about 2.44×10^4.

Actually, a more realistic estimate for the iron would have been 2 Bohr magnetons per atom. That would make the magnetization of iron at saturation about 1,600, which figure agrees fairly well with experimental results. But continue here to use the figure 2.44×10^4.

The volume of Venus is about 1.06 10^{27} c.c.; that of Mars about 1.68×10^{26}. So multiplying by 2.44×10^4 gives the magnetic moments of the planets: 2.60×10^{31} and 4.10×10^{30} respectively.

Consider the planets when they are just about touching, their centers being say 10^9 cm apart. (Which is approximately the sum of their radii.) From what was said above, the force between them, the magnetic force that is, would be $6 \times 2.60 \times 10^{31} \times 4.10 \times 10^{30} / 10^{36} = 6.4 \times 10^{26}$.

From what was said during the discussion of electrostatic forces, the force of gravity between the planets (their centers being 10^9 cm apart) would be about 2.05×10^{29} dynes.

Thus the magnetic force is less than one percent of the gravitational. Moreover, since the magnetic force varies inversely as the fourth power of the distance, the gravitational as the square, at greater distances the comparison would be even less favourable for the magnetic force.

Thus it appears that magnetic forces between the planets could not have had an appreciable effect in re-arranging orbits.

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2 *Ibid.*, Page 11.

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5 Bott, M. H. P. 1971. The interior of the Earth. Edward Arnold, London. Page 178. (Work by Lee in the *Review of Geophysics*, volume I, pages 449-479, is cited.) The flow of heat, from the interior outward, in the Earth, is estimated at 1.5×10^{-6} cal/cm² sec. The solar constant is about 6.6×10^{-2} cal/cm² sec; and this means that the Earth, with an albedo of 0.36, absorbs 4.3×10^{-2} cal/cm² sec from the Sun. (See Reference 4.) Therefore most of the heat lost by the Earth must first come from the Sun. Moreover, the average night temperature of the Earth is 275°K, and the average day temperature 295°K. Both of these temperatures are even higher than the starting temperature used in the calculations.

6 Patten, D. W., *et al.*, 1973. The long day of Joshua, and six other catastrophes. Pacific Meridian Publishing Company. In this work a proposal that Mars might have caused catastrophes in Joshua's time is investigated, but along rather different lines from those followed here.

7 Rose, Lynn E., and Vaughan, Raymond C. 1974. Velikovsky and the sequence of planetary orbits, *Penseé*, 4 (3):27-34. These authors considered several variations on Velikovsky's original suggestion, but do not seem to have included a case like that investigated here.

8 Goldstein, H. 1965. Classical mechanics. Addison Wesley. Page 80.

9 Beiser, A. 1967. Concepts of modern physics. Revised edition. McGraw Hill. Pages 89-91.

10 Chapman, Sydney, and Julius Bartels 1940. Geomagnetism. The Clarendon Press, Oxford. Volume 1. Pages 20-22.

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AN APT APHORISM BY ATHANASIUS

"In regard to the making of the universe and the creation of all things there have been various opinions, and each person has propounded the theory that suited his own taste. For instance, some say that all things are self-originated and, so to speak, haphazard. The Epicureans are among these; they deny that there is any Mind behind the universe at all. This view is contrary to all the facts of experience, their own existence included. For is all things had come into being in this automatic fashion, instead of being the outcome of Mind, though they existed, they would all be uniform and without distinction. In the universe everything would be the sun or moon or whatever it was, and in the human body the whole would be hand or eye or foot. But in point of fact the sun and the moon and the earth are all different things, and even within the human body there are different members, such as foot and hand and head. This distinctness of things argues not a spontaneous generation but a prevenient Cause; and from that Cause we can apprehend God, the Designer and Maker of all."

"Others take the view expressed by Piato, that giant among the Greeks. He said that God had made all things out of pre-existent and uncreated matter, just as the carpenter makes things only out of wood that already exists. But those who hold this view do not realise that to deny that God is Himself the cause of matter is to impute limitation to Him, just as it is undoubtedly a limitation on the part of the carpenter that he can make nothing unless he has the wood. How could God be called Maker or Artificer if His ability to make depended on some other cause, namely on matter itself? If He only worked up existing matter and did not Himself bring matter into being, He would not be the Creator but only a Craftsman."

(From *De Incarnatione Verbi Dei* by St. Athanasius. Translated and edited by a Religious of C. S. M. V. Second Edition. Published by A. R. Mowbray and Co., Ltd., 1953.)

(This item was called to my attention by B. B. Knopp, Eastbourne, England—Editor)