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Calculations and Assumptions for Supporting a Compelling New Model for the Creation of the Earth/Moon System

An excerpt from the book, "Searching for Genesis" details why the Earth and Moon, both terrestrial planets, share the same orbit.

Douglas Ettinger
ETTINGERJOURNALS.COM

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1. Preface

Back in 2013 an article titled, "Earth's Metamorphosis (EMM) Hypothesis" was added to the author's website, EttingerJournal.com. Much later a book was published on July 25, 2020, *Searching for Genesis*. The book principally focuses on the topic of the EMM Hypothesis that addresses the Moon enigma. How did the Earth and Moon form? This question has tantalized NASA and its continuing research following the Apollo missions in the 60s. The subject hypothesis deviates from NASA's inquiry and their existing paradigms. Answers are given – Why do Earth and the planet-like Moon share the same orbit? How did Earth gain its water and atmosphere? Why were continents formed? Why was the Main Belt of Asteroids formed and still exists for the past 4.6 billion years?

This new hypothesis hinges on specially crafted assumptions and manual calculations that were presented in both the article and the book. This paper is an excerpt of these assumptions and calculations that formed the basis for the Earth/Moon creation. *The author is hoping to stimulate more awareness and interest by offering monetary rewards to students or other persons in academia who examine these calculations for their assumptions, numerical correctness, and more importantly for errors in applying the physical laws. More rewards will be given to any talented physicist who can apply computerized numerical simulation to this unique model. The current offering for any reviewer that finds an error in the applied physical laws of these calculations will receive $200 for each one that is properly reported to the author.*

Calculations and Assumptions for Supporting a Compelling Model for the Creation of the Earth/Moon System

2. Introduction

The following assumptions and calculations try to make sense of a combination collision-and-capture model presented as the Earth's Metamorphosis (EMM) hypothesis. Briefly, Earth originally resides in an orbit between Mars and Jupiter close to the 'snowline' near the beginning of the solar system's formation and is struck by an icy rogue planet that creates debris now called asteroids. Earth is then displaced sunward and as its falling velocity increases a new orbit occurs very close to an existing terrestrial planet, which is now called the Moon. After exchanging gravitational energy and angular momentum they form a synchronist orbit together. These ideas come from the subject mathematical treatise that set up boundaries such as the impactor mass and velocity, angle of approach, original Earth's mass and velocity, latitudinal location of impact, the trajectory of displaced Earth, and approximate mass of collisional debris. If certain boundaries were exceeded, then the calculations would not produce the final result that was expected. Then a re-iteration of certain assumptions continues until the expected results are achieved.

The final mass of Earth, the final orbital properties of Earth and Moon, the mass of the Moon, the orbital span of the Main Belt of Asteroids, and its estimated mass are all known or given data or starting points. The physical laws and their equations such as the Conservation of Energy, Conservation of Angular and Linear Momentum, the Coefficient of Restitution, Newton's Laws of Motion, and the Universal Gravitation Force are applied. Some rough calculus is applied to the Earth's trajectory between the center of its original orbit within the Main Belt of Asteroids at 2.7 AU and the Moon's orbit at one AU from the Sun.

3. Abstract for the Earth's Metamorphosis (EMM) Model

The mathematical modeling starts with the following question. What size of an Impactor or Rogue Planet and its initial velocity is required to knock planet Earth from an orbit in the Main Belt of Asteroids to the Moon's orbit?

An Impactor between the size and mass of Ganymede and Mars is assumed to strike the young Earth when it formerly resided in an orbit roughly the mean average of the present asteroids orbiting between Mars and Jupiter. Another reasonable assumption proposes that the Earth's original orbital velocity was close to the current average orbital velocity of the asteroids.

The original Impactor's mass adds to the Earth's original mass, less some small mass for the ejected debris assuming a very close coefficient of restitution of zero. The collisional debris becomes the most substantial portion of the Main Belt of the asteroids' mass. A factor of four times this amount of debris is imposed to account for the other collisional debris that struck Mercury, the Moon, and Mars, with some falling back to Earth. Some of this debris may have become parts of the irregular orbiting asteroids outside the Main Belt, the Trojan asteroids in Jupiter's orbit, the moons of Mars, and collisions with the Sun and other planets. This collision event is attributed to the Late Heavy Bombardment (LHB) of the inner solar system. The volume of the Impactor is a calculated value after choosing a typical mean density using other solar system objects of similar composition and mass as a guide.

The assumed value for the velocity of the merged Impactor and the Earth immediately after impact is calculated. A certain velocity is required for an initial trajectory vector that will eventually create a synchronous orbit with the Moon at one astronomical unit, AU, from the Sun. Other essential assumptions are the resulting velocity vector after impact that is toward the Sun at an oblique angle and that the trajectory remains in the ecliptic plane where it is estimated that Earth orbited originally.

The following conservation of energy and momentum equations assume impact losses, about 10 % of the total energy transferred. Initially, this 10% is a complete guess but becomes inductive after other energy quantities are computed and tabulated. These quantities are the energy required to aid in tilting the spin axis, displacing Earth's orbit, increasing material pressures to penetrate the Earth's crust and mantle; creating noise, light, and heat; and finally the kinetic energy to disperse the collisional debris.

The conservation of momentum equation for less than perfect inelastic collision such as an ice ball thrown at a snowman and penetrating it determines the resulting momentum vector and new velocity of the combined bodies. The conservation of energy equation sums the “before and after” kinetic and potential energies of the bloated Earth and the Impactor inside its mantle as it moves from between Mars and Jupiter to its present orbit. The new velocity of the impacted Earth immediately after impact is determined from the conservation of momentum equation and then used in the conservation of energy equation.

Chosen values for the first equations are determined and listed:

1. Earth's original mass before the collision equals the Earth's current mass less than the Impactor's mass is equal to 5.72 x 10^{24} kg. (Earth's current mass) 5.97 x 10^{24} kg.

2. The estimated total mass of dispersed debris created from the impact is equal to 0.012 x 10^{24} kg or (NASA's estimate of the Main Belt asteroids' mass 0.003 x 10^{24} kg x 4.)

3. The average orbital velocity of bodies in the Asteroid Belt and the original orbital velocity of Earth equals 18.5 km/sec.

4. Assumed mass for the Impactor is 0.25 x 10^{24} kg = 0.25/5.97 = .042 of Earth's mass (for reference - Ganymede's mass of mostly ices is 0.15 x 10^{24} kg, and Mars' mass, which is 0.107 of Earth's, is 0.64 x 10^{24} kg).

5. Assumed velocity of Impactor before collision (see Impact Velocity Calculation) is 45 km/sec (Orbital speed of Mars – for reference is 24 km/sec; Fastest impacts occurring on Earth – for reference = 70 km/sec; Impact velocity of Comet Shoemaker-Levy 9 with Jupiter – for reference is 60 km/sec).

6. Assumed density of Impactor (this density indicates a small iron core with a crust and outer mantle of mostly ices with a smaller silicate inner mantle) = 2.500 g/cm^3 (Ganymede's mean density for reference is 1.936 g/cm^3; Io's mean density for reference is 3.528 g/cm^3; Mars' mean density for reference is 3.934 g/cm^3; Common densities for reference are 1.00 for water; 2.7 for granite; 7.8 or iron; 5.52 for Earth; 13.0 for the Earth's core.)

7. Volume of Impactor (determined by chosen density and mass) = 10.0 x 10^{10} km^3. (Volume of Earth = 108 x 10^{10} km^3; Volume of Mars is 16.3 x 10^{10} km^3; and Ganymede is 7.6 x 10^{10} km^3 for reference.)

8. Distance between Earth's original and current orbits = (2.7 – 1.0) AU = 1.7 AU; 1.7 AU x 149 x 10^6 km / AU = 2.53 x 10^8 km.

9. Assumed distance between Earth's initial and Moon's original orbits = 0.234 x 384,400 km (Moon's current distance) = 90,000 km.

10. Sun's current mass = 1.99 x 10^{30} kg.

11. Moon's current mass = 7.34 x 10^{22} kg.

12. Earth's and Moon's current orbital velocity = 30 km/s

13. Gravitation constant(G) 6.674 x 10^{-11} $m^3 kg^{-1}$ sec^{-2} or 6.674 x 10^{-11} (Nt)m^2 kg^{-2} or 6.674 x 10^{-20} km^3 kg^{-1} sec^{-2}.

14. One AU = distance between Earth and Sun, which is 1.49 x 10^8 km.

15. Conservation of momentum equation for a perfectly inelastic collision m_1 (u_1) + m_2 (u_2) = (m_1 + m_2) (v)

16. Kinetic energy equation K.E. = K = ½ m v^2.

17. Potential energy equation P.E. = Ug = - G (m_1)(m_2) / (Radius).

18. The conservation of energy used for the Earth with its captured Impactor falling from the orbit between Mars and Jupiter to its current orbit is a sum of energies = K_0 + Ug_0 = K_f + Ug_f where K_0 + Ug_0 = energies of combined bodies near asteroid Main Belt orbit and K_f + Ug_f = energies of combined bodies near Earth's current orbit

More explanations of assumptions follow:

1. The Earth's original mass before the collision is based simply on the difference between the Earth's current mass and the assumed mass of the Impactor. The Impactor is expected to penetrate and add most of its mass to Earth's mass.

2. The estimated cumulative mass of debris from the impact is more than the

cumulative asteroid Main Belt mass of 0.003 to 0.0036 x 10^{24} kg determined by a NASA survey and extrapolations. This Main Belt mass does not include the other asteroid masses that struck the Moon, fell back to Earth, and possibly contributed to the Trojan asteroids of Jupiter, and other highly elliptical/inclined asteroids. Hence, more mass is added to the Main Belt mass and assumed as a factor of 4 times more. However, this mass summation of 0.012 x 10^{24} kg is still negligible when compared to the total masses of the Earth and the Impactor. Therefore, the following calculations utilizing the conservation of momentum and conservation of energy ignore this mass.

3. The Earth's original orbital velocity is assumed and chosen from the estimated average orbital speed of the asteroids found in the Main Belt. The velocities of the two largest asteroids, Ceres and Vesta, are 17.88 km/s and 19.29 km/s, respectively. The assumed orbital velocity falls between the adjacent orbital velocities of Mars at 24 km/s and Jupiter at 13 km/s. It is sensible to choose 18.5 km/s as Earth's original velocity because any object at this orbital radius has a similar orbital velocity, whether it existed in the distant past or the present.

4. The choice of the assumed mass of the Impactor is more difficult. In combination with the value of its velocity, enough momentum diverts the velocity vector of the original Earth's momentum from its initial orbit into an inward trajectory that falls far enough to increase its velocity sufficiently for an inner orbit. Its final velocity vector must come very close to a tangent line with the Moon's orbit, and at the same time achieve approximately the Moon's orbital velocity.

The hefty mass of Mars was considered first since certain academic theorists currently had no qualms using it to strike Earth and create debris that then accreted to form the Moon in a Giant Impact Theory. My scenario is quite different and need not account for enough mass to create the Moon, but Impactor momentum needs to be sufficient to divert Earth from its given orbit. The composition of the Impactor is also very different from Mars, being made primarily of ices and silicates, as opposed to a majority of rocky materials needed to make Mars and the Moon.

The selection of the assumed mass and density should be reasonably comparable to known ice/rocky bodies in our solar system. Two comparable bodies are Jupiter's moon, Ganymede, with a mass of 1.48 x 10^{23} kg and a mean density of 1.936 g/cm^3 and Mars with a mass of 0.64 x 10^{24} kg and a mean density of 3.934 g/cm^3. Considerations for the volume and size of the Impactor are based on having a smaller mass and less density than Mars. The Impactor's mass is 0.25 x 10^{24} kg selected by making a comparative study of various celestial bodies. See the Table of Comparative Data for Solar System Objects.

5. The assumed velocity of the Impactor is also a tricky choice. The value needs to provide sufficient momentum (m x v). The orbital velocity of Mars, the next inner planet to the Earth's original position, is 24 km/sec. The fastest orbital velocity for a planet is 48 km/sec for Mercury. The velocity of impact for Comet Shoemaker-Levy 9 was 60 km/sec. These velocities can provide some guidance. Perhaps its normal orbital velocity was between 25 and 35 km/s; then, the Impactor accelerated to 40 to 50 km/s as it was falling toward Earth.

One possible scenario is that a large Neptunian-size rogue planet became captured and perturbed into a long elliptical orbit that crossed the Main Belt orbital path. One of its own larger satellites struck the Earth. The combined velocities of both the planet and the satellite could have created an unusually high combined velocity.

Another perhaps more accurate line of thought comes from the study of impact velocities. On Earth, ignoring the slowing effects of travel through the atmosphere, the lowest impact velocity with an object from space is equal to the gravitational escape velocity of about 11 km/s. The fastest impacts occur at more than 70 km/s, calculated by summing the escape velocity from Earth, the escape velocity from the Sun at the Earth's orbit, the escape velocity from the Impactor if sufficiently large, and the motion of the Earth around the Sun. During the early stages of the Earth's formation, there was less atmosphere to slow an incoming object. A separate calculation for impact velocity was performed.

6. The assumed composition is more ice than rocky materials that are comparable to the make-up of Jupiter's moon, Ganymede. Its density is chosen to match an icy moon as opposed to a terrestrial planet. Hence, the density falls between

Ganymede's 1.94 g/cm^3 and the Moon's 3.34 g/cm^3, but closer to Ganymede's density.

7. The Impactor's volume is simply the result of its chosen density and mass. However, this volume should have reasonable proportions to the size of Earth, since most of the Impactor is embedded inside the Earth's mantle.

8. The assumed original orbital radius of 2.7 AU for Earth was determined to be close to the values of the two largest asteroids: Ceres at 2.77 AU and Vesta at 2.36 AU and fall between the orbital velocities of Mars and Jupiter.

9. The Earth did not align perfectly with the Moon's orbit when it relocated. Otherwise, a collision would occur. The Moon was closer at 90,000 km during its first encounter with Earth. Angular momentum and energy are transferred between the two objects in various steps to allow movement of the Moon to its present orbit around Earth and make the Earth's orbit more circular and slower. A computed change of the distance between the two bodies eventually reduced the calculated Earth's velocity of 35 km/s when it reached the Moon's orbit to today's orbital velocity of 30 km/s.

10. The energies expended in the collision include those that make noise, light, and heat; disperse debris into space; compress and displace both bodies' mantles; reduce the rotations of both bodies, tilt the spin axis, and most importantly change the orbital radius and orbital directions. The conservation laws will only consider the difference in orbital radius and velocity vectors and the choice of 10 % losses for all the other energy expenditures. This factor of losses is the largest question in this list of assumptions and perhaps can be estimated better with more accurate calculations in the future.

11. The impact angle for a tangent of the Earth's surface is between 90 to 70 degrees so it is assumed little angular momentum is transferred to alter the spin of the Earth. Hence, only linear momentum is used for the momentum conservation calculation.

12. The Earth's tilt of its spin axis is caused by the imbalance of the much lighter Impactor materials embedded inside the Earth's mantle, offsetting the center of

gravity and by some unknown initial impact energy. The Earth's gyroscopic motion helps to preserve its original spin axis. However, over a very short time, this imbalance of the two different spinning masses causes the overall spin to seek equilibrium and tilt the axis by 23 degrees with respect to the ecliptic plane. The tilt is stabilized by the aid of the Moon's external gravity field after the two planets begin to share one orbital region.

Hopefully, these assumptions have not veered too far from past reality so that a plausible model is developed to re-create this catastrophic event of our genesis story involving the Earth and Moon system. An essential part of science is understanding uncertainty. When scientists say we know something, we mean we have tested their ideas with a degree of accuracy over a range of scales. Scientists also address the limitations of their theories and try to define and extend the range of applicability. If the method here is appropriately applied, similar, but even more accurate results should emerge over time. This model, with all its assumptions, bravely attempts to address all the more critical enigmas about the Earth-Moon system starting with some simple ideas. The model attempts to incorporate the necessary scientific disciplines of astrophysics, planetary science, geology, and non-computerized mathematics.

It is our responsibility to push reason as far as we can. Far from being isolated, a rational, scientific way of thinking could be unifying. Evaluating alternative strategies; reading data, when available, understanding hidden meanings of space probe explorations; and, understanding their uncertainties – all features of the scientific method – can help us find the right way forward.

4. Tabulations for Values Used in Equations:

1.	Earth's original mass before the collision equals the Earth's current mass - the impactor's mass	5.72×10^{24} kg
	(Earth's current mass)	5.97×10^{24} kg
2.	The estimated total mass of dispersed debris created from the impact	0.012×10^{24} kg
	(NASA's estimate of Main Belt asteroids' mass)	0.003×10^{24} kg
3.	Avg. orbital velocity of bodies in the Asteroid Belt and the original orbital velocity of Earth	18.5 km/sec

4.	Assumed mass for the Impactor	0.25×10^{24} kg = .25/5.97 = .042 of Earth's mass
	(Ganymede's mass of mostly ices – for reference)	0.15×10^{24} kg
	(Mars' mass, which is 0.107 of Earth's – for reference)	0.64×10^{24} kg
5.	The assumed velocity of the Impactor before the collision (see Impact Velocity Calculation)	45 km/sec
	(Orbital speed of Mars – for reference)	24 km/sec
	(Fastest impacts occurring on Earth – for reference)	70 km/sec
	(Impact velocity of Comet Shoemaker-Levy 9 with Jupiter – for reference)	60 km/sec
6.	The assumed density of Impactor (this density indicates an iron core with a crust and outer mantle of mostly ices with a smaller silicate inner mantle)	2.500 g/cm^3
	(Ganymede's mean density for reference)	1.936 g/cm^3
	(Io's mean density for reference):	3.528 g/cm^3
	(Mars' mean density for reference):	3.934 g/cm^3
	(1.00 for water; 2.7 for granite; 7.8 or iron; 5.52 for Earth; 13.0 for Earth's core)	
	(see Table of Comparative Data for Solar System Objects for selecting Impactor parameters)	
7.	The volume of Impactor (determined by chosen density and mass)	10.0×10^{10} km^3
	Volume of Earth	108×10^{10} km^3
	(Volume of Mars is 16.3×10^{10} km^3; Ganymede is 7.6×10^{10} km^3 for reference)	
8.	Distance between Earth's original and current orbits = (2.7 – 1.0) AU = 1.7 AU x 149×10^6 km / AU	2.53×10^8 km
9.	Assumed distance between Earth's current and Moon's original orbits = 0.24 x Moon's current distance	92,400 km
10.	Sun's current mass	1.99×10^{30} kg
11.	Moon's current mass	7.34×10^{22} kg
12.	Earth's and Moon's current orbital velocity	30 km/s
13.	Gravitation constant (G)	6.674×10^{-11} m^{3}kg^{-1} sec^{-2} or 6.674×10^{-11} (Nt)m^2 kg^{-2} or

		6.674×10^{-20} km^3 kg^{-1} sec^{-2}
14.	One AU	1.49×10^8 km
15.	Conservation of momentum equation for a perfectly inelastic collision	$m_1 (u_1) + m_2 (u_2) = (m_1 + m_2) (v)$
16.	Kinetic energy equation	K.E. = K = ½ m v^2
17.	Potential energy equation	P.E. = U_g = - G $(m_1)(m_2)$ / (Δ Radius)
18.	The conservation of energy used for the Earth with its captured Impactor falling from the orbit between Mars and Jupiter to its current orbit	Sum of energies = $K_0 + U_{g0} = K_f + U_{gf}$ where $K_0 + U_{g0}$ = energies of combined bodies near asteroid Main Belt orbit and $K_f + U_{gf}$ = energies of combined bodies near Earth's current orbit

5. Comparative Data for Solar System Objects:

Object	Volume 10^{10} km^3 (Earth's)	Mean Radius km (Earth's)	Density g/cm^3	Mass 10^{24} kg (Earth's)	Features
Ganymede	7.6 (0.0704)	2634 (0.413)	1.94	0.148	Fe/FeS core; outer ice mantle; inner silicate mantle; fully differentiated.
Pluto	0.639 (0.006)	1153 (0.18)	2.03	0.013 (0.00218)	50% ice 850 km tk. and 50% rock; has N_2, CH_4, and CO_2 ices.
Ceres	0.048 (0.0004)	487 (0.076)	2.08	0.0009 (0.00015)	Water ice 100 km tk. with rocky core; ½ mass of asteroid main belt.
Moon	2.19 (0.020)	1737 (0.273)	3.34	0.073 (0.0123)	Has mafic mantle and iron liquid and solid core; 2nd densest satellite in solar system behind Io

Io	2.53 (0.023)	1821 (0.286)	3.53	0.089 (0.015)	Fe/FeS core; outer silicate crust; partially molten silicate mantle.
Mars	16.32 (0.151)	3398 (0.533)	3.97	0.64	Fe/S core; silicate mantle; Earth's crust averaging 40 km is only 1/3 as thick as Mars' crust.
Earth	108.3	6378	5.52	5.97	Fully differentiated with N_2 and O^2 atmosphere and liquid H_20.
Impactor	**10.0 (0.092)**	**2880 (0.452)**	**2.5**	**0.250 (0.042)**	**similar to Ganymede**

6. Choosing the Parameters for Earth's Impactor

The table above provides a brief study of asteroids, moons, and dwarf planets. From their properties, the Earth's Impactor parameters are selected from the possible range in sizes. The Impactor is assumed to be a normal celestial body presently found in the solar system or any other star system for that matter.

1. The range of sizes is Ganymede's radius of 2634 km to Ceres and Enceladus radii of 487 km and 252 km, respectively. Mars' radius size of 3398 km is also in the running.
2. Typically, the volumes of these bodies range from 0.006 to 0.070 Earths.
3. The maximum mean densities are about 3.34 g/cm^3 for the Moon, Io, and Europa. The average densities are around 2.0 g/cm^3 for reflecting large mantles of ices and silicates with a rocky core or small iron core. Objects with densities between 1.6 and 1.0 g/cm^3 are composed mostly of ices and are the least differentiated.
4. Typically, bodies with lower densities have compositions with smaller iron/iron sulfide/sulfur cores and with inner silicate mantles and outer ice mantles. The crusts are generally ices, except for the denser bodies that have rocky surfaces with traces of an atmosphere. The outer ices are composed of the most common elements and compounds in the solar system: O_2, N_2, H_20, CO_2, NH_3, NO_X, and CH_4. To provide enough kinetic energy to knock Earth into another orbit, but not too much energy to destroy the very soft, molten, young Earth, the Impactor parameters are chosen as:

Mean density = 2.50 g/cm^3; Volume = 10.0 x10^{10} km^3; Radius = 2880 km; Mass = 0.25 x 10^{24} kg; and, Composition = soft small iron/iron sulfide core; molten silicate mantle of 1750 km radius and an outer mantle of hard ices made of the previously mentioned elements and compounds.

7. Impact Velocity Calculation

A planetary impact velocity is the sum of the escape velocity from Earth, the escape velocity from the Sun at the Earth's orbit, the escape velocity of the impacting body if sufficiently large, and the motion of the Earth around the Sun. Hence, ve-Earth = Earth's escape velocity = 11.2 km/s;   vEarth = Earth's orbital speed = 18.5 km/s at 2.7 AU from the Sun; ve-Sun ≈ Sun's escape velocity ≈ 26.3 km/s at 2.7 AU from the Sun; ve-Impactor = √(2GM/r) where G = gravitational constant, M = mass of Impactor, and r = radius of Impactor = √(2 x 6.674 x 10^{-20} $km^3\ kg^{-1}\ s^{-2}$ x 0.25 x 10^{24} kg / 2850 km) = √(11.82) km^2/s^2 = 3.43 km/s.

Hence, the collision geometry for two coplanar space objects with an approach angle of 90 degrees generates the following result.

vI = impact velocity   = √[(vEarth)^2 + (ve-Earth + ve-Sun + ve-Impactor)^2]; the Earth's orbital velocity is assumed to be 90 degrees to the impact velocity; hence the two vectors are added to achieve a resultant vector = √[(18.5)^2 + (11.2 + 26.3 + 3.4)^2] km/s   = √(342 + 1673) km/s   = 44.9 km/s

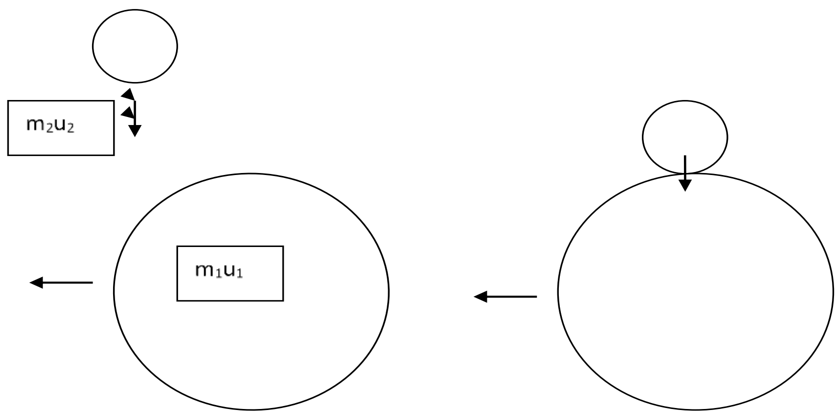
Hence, 45 km/s becomes the Impactor's impact velocity. This velocity seems to be a reasonable value when comparing it with other known impact velocities.

8. Calculations for the Collision Impulse and Linear Momentum Change

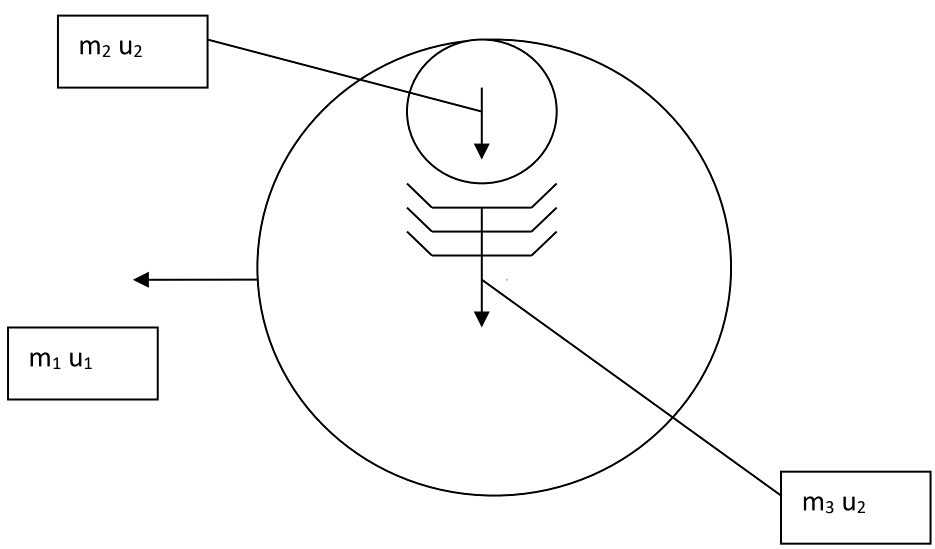
A sizable object called the Impactor strikes the Earth and embeds itself inside the Earth's mantle, causing a resulting change in the linear momentum of the combined objects. Various linear momentums equal to the mass of the body (m) times the velocity of the body (u or v) are calculated. The impulse of collision is equal to the force times the length of time the force acts (F x t). However, the impulse more easily determines the setting F x t = change in momentum = m (v_t – v_o) = the mass' change in velocity during the impulse event. The original momentum of the Impactor is set equal to (m_2 x u_2). The original momentum of Earth is set equal to (m_1 x u_1).

The impulse of the Impactor completely penetrating the Earth's crust and mantle is estimated to be equal to (m_2 x u_2). The impulse of the Earth's mantle being displaced by moving downward and mostly sideways is estimated to be equal to (m_3 x u_2). The Earth's displaced mantle mass, m_3, is set equal to the Earth's average mantle density times the Impactor's volume. The following diagrams graphically represent the resolution of these momentum vectors.

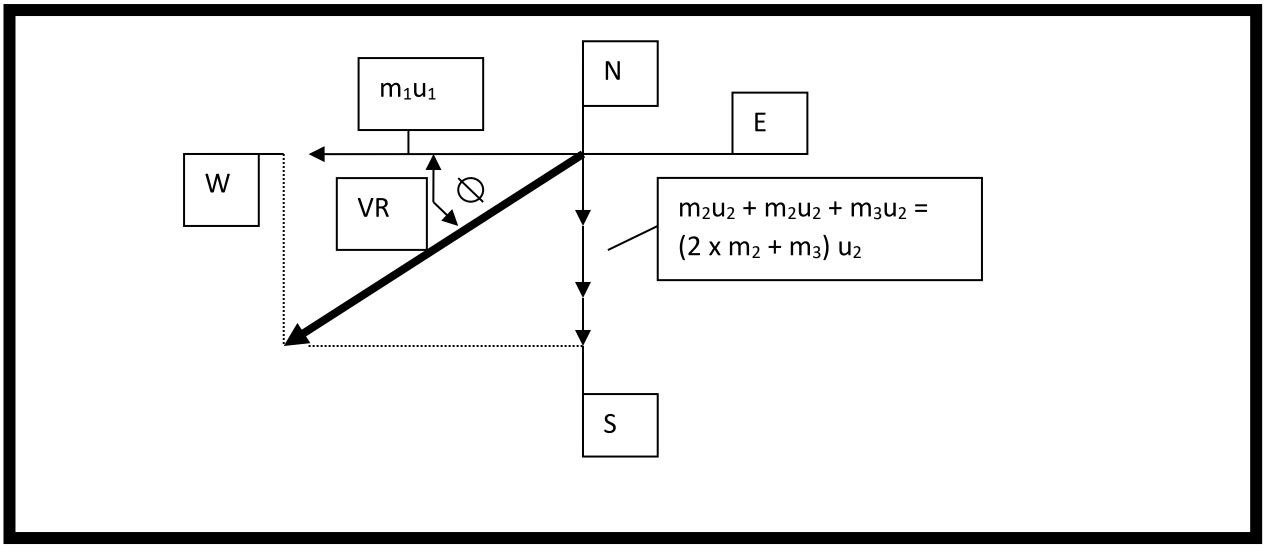
Diagrams for Resolving Impulse of Impact and Momentum Vectors



Conditions Before Impact



Conditions Immediately After Impact



Resolving the Components of Linear Momentum

The resolution of vectors becomes:

m_1u_1 = (5.97 – 0.25) x 10^{24} kg x 18.5 km/s = Earth's momentum = 5.72 x 10^{24} kg x 18.5 km/s = 105.8 x 10^{24} kg km/s

m_2u_2 = 0.25 x 10^{24} kg x 45 km/s = Impactor's momentum = 11.25 x 10^{24} kg km/s

V_2 = the volume of the Impactor = m_2/σ_2 (mass/density) = 0.25 kg x 10^{24} kg/2.50 g/cm^3 = 10.0 x 10^{10} km^3 (Ganymede is 7.6 x 10^{10} and Mars is 16.3 x 10^{10})

r_2 = radius of Impactor = $\sqrt[3]{[(3/4\pi) \times V_2]}$ = $\sqrt[3]{[0.239 \times 0.100 \times 10^{21}\ m^3]}$ = $\sqrt[3]{[0.239 \times 10^{21}\ m^3]}$ = 0.288 x 10^7 m = 2880 km (Ganymede is 2634 km and Mars is 3398 km)

$m_3 = \sigma_1$ x V_2 (average density of Earth's upper and lower mantle x volume of Impactor) = [(5.6 + 3.4)/2] x 10.0 x 10^{10} km^3 = 4.5 g/cm^3 x 10.0 x 10^{10} km^3 = 0.45 x 10^{24} kg

m_2u_2 = impulse to compress and push Impactor into Earth's mantle ≈ Impactor's original momentum = 0.25 x 10^{24} kg x 45 km/s = 11.25 x 10^{24} kg km/s

m_3u_2 = impulse to displace and/or compress Earth's mantle outward to make room for the Impactor volume = 0.45 x 10^{24} kg x 45 km/s = 20.25 x 10^{24} kg km/s

The north-south components of momentum after factoring in 10% energy losses add to:

$\sum M_{N}s$ = 0.9 (11.25 + 11.25 + 20.25) kg km/s = 38.48 kg km/s

The east-west components of momentum after factoring in 10% energy losses add to:

$\sum M_{ew}$ = 0.9 (105.8 x 10^{24}) kg km/s = 95.22 kg km/s

R = the resultant linear momentum = √ [$(95.22)^2$ + $(38.48)^2$] = √ [10,548] = 102.7 x 10^{24} kg km/s

vR = resultant velocity of combined Earth and Impactor = R/ (m_1 + m_2) = (102.7 x 10^{24} kg km/s) / (5.97 x 10^{24} kg) = 17.20 km/s

Direction of R is tan ϴ = 38.48/95.22 = 0.404 and the angle is -

ϴ = 22 degrees pointing inward from its present orbit and co-planar with the other planetary orbits.

9. Determination of Earth's Trajectory

The new resultant velocity, with its inward direction, needs to meet the restrictions of the Sun's gravitational field. Hence, the following concepts are discussed.

v_c = orbital velocity = √(gr) = lowest possible orbit, which is circular where g is the acceleration of gravity, and the orbital radius is r.

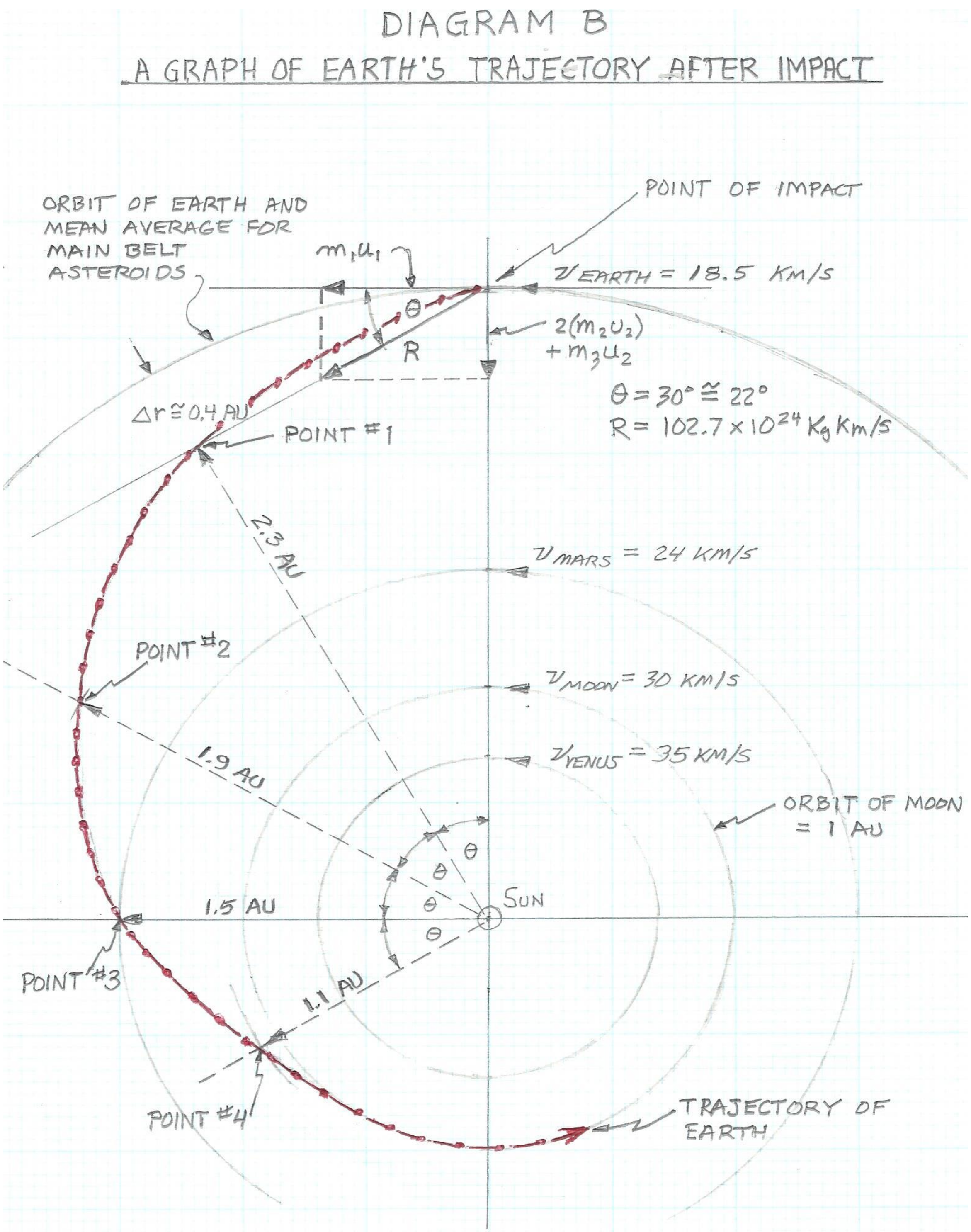
v_e = escape velocity = √2 x v_c = √(2gr) = √(2GM/r) = minimum orbital velocity for an open orbit which has either a parabolic or hyperbolic trajectory. G is the gravitational constant, and M is the Sun's mass.

v_o = any velocity for a closed elliptical or circular orbit becomes: $v_c \leq v_o < v_e$

Hence, vR for the new trajectory of this impacted Earth needs to meet these restrictions; otherwise, the Earth will keep falling into the Sun or escape the solar system via an open orbit. When the impacted Earth comes close to the Moon's orbit, it needs to be higher but closer to the value of v_c to retain an elliptical (almost circular) orbit merging with the Moon's orbit.

Refer to the plotted graph, Diagram C, which shows roughly to scale of the inward spiraling trajectory and the source of some of the data used in the next set of calculations. Different points are selected along Earth's trajectory, as shown in Diagram B. Energy conservation calculations are made for Earth's motion between each of the selected points #1 through #4.

10. Graph of Earth's Trajectory Toward the Sun After Impact



The new trajectory of Earth brings it approximately 0.4 AU closer to the Sun at the intersection of its tangent line with a radius line from the Sun. At this point #1 escape velocity from the Sun's gravity is:

ve1 = √(2GM/r1) = √(2GM) x √(1/r1) where r1 = 2.7 – 0.4 = 2.3 AU = √(2 x 6.674 x 10^{-20} km^3 kg^{-1} s^{-2} x 1.99 x 10^{30} kg) x √{(1/2.3AU) x (1AU/149,597,870 km)} = √(26.563 x 10^{10} km^2 s^{-2} x √(0.292 x 10^{-8}) = (5.154 x 10^5) x (0.539 x 10^{-4}) km/s = 27.8 km/s

At this same point #1 orbital velocity from the Sun's gravity is:

vc1 = ve1 / √ (2) = (27.8 km/s) / 1.414 = 19.66 km/s

The Earth has fallen closer to the Sun by 0.04 AU at point #1. The conservation of energy is applied by summing the potential and kinetic energies before and after.

∑ Ei = (K + Ug) i = sum of energies at initial point, and

∑ E1 = (K + Ug)1 = sum of energies at point #1

Hence: K1 = Ki + (- U1) - (-Ui)

Then: ½ m$(v1)^2$ = ½ m$(vR)^2$ + (- GMm/r1) - (- GMm/rR)

Canceling the "m's" and solving for "v1" yields:

v1 = √ [vR2 + 2 GM (1/r1 – 1/rR)]

Solving for v1 = velocity at point #1 -

v1 = √ [$(17.2)^2$ + (2 x 6.674 x 10^{-20} km^3 kg^{-1} s^{-2} x 1.99 x 10^{30} kg) x (1AU/149,597,870 km) x (1/2.3 AU – 1/2.7 AU)]

v1 = √ [296 + (1775 x {0.4348 – 0.3704})] = √ [296 + 114.3] = 20.26 km/s

v1 is more than orbital velocity at point #1, and, hence, the displaced Earth continues to fall inward on a spiral path.

The Earth at point #1 continues to fall toward the Sun at v1 = 20.26 km/s. Point #2 is chosen where the Earth has fallen another 0.4 AU closer or 2.7 AU – 0.8AU = 1.9 AU from the Sun. The escape velocity is now:

ve2 = √(2GM/r2) = √(2GM) x √(1/r2) [where r2 = 2.7 – 0.8 = 1.9 AU] = √(2 x 6.674 x 10^{-20} km^3 kg^{-1} s^{-2} x 1.99 x 10^{30} kg) x √{(1/1.9 AU) x (1AU/149,597,870 km)} =

$\sqrt{}(26.563 \times 10^{10}$ km^2 s^{-2} x $\sqrt{}(0.352 \times 10^{-8})$ = $(5.154 \times 10^5) \times (0.594 \times 10^{-4})$ km/s = 30.6 km/s

The orbital velocity at point #2 is:

vc2 = ve1 / $\sqrt{}$ (2) = 30.6 / 1.414 = 21.64 km/s

The conservation of energy is applied again for going from point #1 to point #2 where r1 = 2.3 AU and r2 = 1.9 AU.

v2 = $\sqrt{}$ [v1^2 + 2 GM (1/r2 – 1/r1)] = $\sqrt{}$ [(20.26)^2 + (2 x 6.674 x 10^{-20} km^3 kg^{-1} s^{-2} x 1.99 x 10^{30} kg) x (1AU/149,597,870 km) x (1/1.9 AU – 1/2.3 AU)].

v2 = $\sqrt{}$ [410.5 + (1775 x {0.5263 – 0.4348})] = $\sqrt{}$ [410.5 + 162.4] = 23.93 km/s

Now Earth's velocity at point #2 is between the minimum escape velocity and orbital velocity. Hence, Earth is continuing to spiral inward.

The third point in its trajectory is chosen at another Δr = 0.4 AU closer to the Sun or 2.7 – 1.2 = 1.5 AU from the Sun which is now the orbital distance of Mars. Of course, a collision with Mars or a strong effect on its orbit or an effect on the Earth's trajectory is avoided since Mars' position was more than likely far enough away or even, probably opposite Earth's crossing.

The escape velocity with respect to the Sun at Mars' orbital position is:

ve3 = 34.1 km/s

The orbital velocity is:

vc3 = ve3 / $\sqrt{}$ (2) = 24.11 km/s which is the orbital velocity of Mars.

Applying the conservation of energy for Earth going from point #2 to point #3 where r2 = 1.9 AU and r3 = 1.5 AU.

v3 = $\sqrt{}$ [v2^2 + 2 GM (1/r3 – 1/r2)] = $\sqrt{}$ [(23.95)^2 + (2 x 6.674 x 10^{-20} km^3 kg^{-1} s^{-2} x 1.99 x 10^{30} kg) x (1AU/149,597,870 km) x (1/1.5 AU – 1/1.9 AU)].

v3 = $\sqrt{}$ [572.6 + (1775 x { 0.6667 – 0.5263 })] = $\sqrt{}$ [572.6 + 249.2] = 28.67 km/s

Again, the Earth is still spiraling inward having a value between escape and orbital velocities. The escape velocity with respect to the Sun near the approaching Moon's orbit is:

ve4 = 42.1 km/s

The orbital velocity is:

vc4 = ve4/√ (2) = 42.1/1.414 = 29.77 km/s which is basically that of the current Moon and Earth.

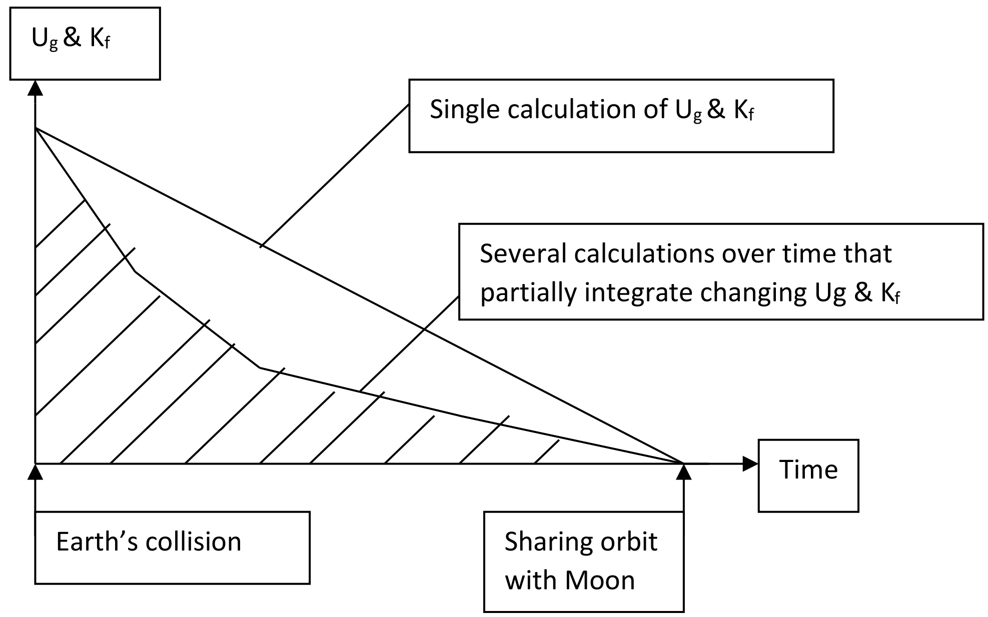
Applying the conservation of energy once again for the Earth moving from point #3 to point #4 where r3 = 1.5 AU and r4 = 1.1 AU:

v4 = √ [$(28.67)^2$ + (2 x 6.674 x 10^{-20} km^3 kg^{-1} s^{-2} x 1.99 x 10^{30} kg) x (1AU/149,597,870 km) x (1/1.1 AU – 1/1.5 AU)] = √ [822.0+ (1775 x {0.9091 – 0.6667})] = √ [822.0 + 430.3] v4 = 35.39 km/s

A tabulation of the numerical results of a falling Earth follow

Point or position	Description	AU from the Sun	Earth's velocity, v km/s	Orbital velocity, v_c km/s	Escape velocity, v_e km/s
0	Original orbit in Main Belt	2.7	18.5(17.2)	18.2	25.7
1	New trajectory tangent to the radius from Sun	2.3	20.26	19.7	27.8
2	Incrementing trajectory position every 0.4 AU	1.9	23.9	21.6	30.6
3	Position when crossing Mars' orbit	1.5	28.7	24.1	34.1
4	Approaching Moon's orbit at 1 AU	1.1	35.4	29.8	42.1

Comparison for Integrating Energy Changes as Earth Falls Toward Sun



The escape velocity of Earth in its original orbit is -

ve0 = √(2GM/r0) = √ {(2 x 13.28 x 10^{10})/ (2.7 AU x 149 x 10^{6})} = 25.7 km/s

Then the Earth's orbital velocity is -

vc0 = ve0/√ (2) ≈ 18.2 km/s

* Earth's velocity after it collided with a rogue planet is computed as 17.2 km/s with an inward trajectory.

The calculations and above tabulation reveal a possible scenario. Also, refer to the graph of Diagram B; the velocity of Earth increased as it fell toward the Sun exceeding orbital velocity at all points #1, #2, #3, and #4, thus assuring an elliptical orbit but never exceeding escape velocity.

The Earth passed Mars' orbital region at an oblique angle to the Martian orbital path. Perhaps Mars was far enough away not to seriously perturb the Earth's trajectory or Mars' orbit.

At about 1.1 AU, the Earth was aligned very close to a tangency with the Sun's radius as revealed by Diagram C. The calculation indicates that Earth was traveling faster than the orbital velocity determined to be 30 km/s at one AU. The Earth was destined to follow a more elliptical orbit than the Moon at this position with its faster velocity computed at about 35 km/s. However, the Earth most probably passed close enough to the Moon on its first orbit for the two bodies to have a close encounter and become connected gravitationally. The first few thousands of passings of the two planets in almost concentric parallel orbits slowed the Earth's velocity as it passed the Moon each time. This initial energy exchange is approximated in a follow-up calculation.

The Earth and Moon would forever become captured within the same orbit after energy transfer took place as the faster Earth passed the Moon during a certain number of orbits. During each passing, the Earth's velocity reduced incrementally until their orbital speeds and orbital ellipses became well-matched. In turn, the Moon exchanges higher and lower orbits during each passing to conserve the transfer of energy and momentum.

Another conservation of energy calculation checks the overall results of the Earth's changing orbits immediately after its impact. This calculation accounts for the entire re-location of Earth from the asteroids' Main Belt to the Moon's orbit.

$\sum$ Energies = Ko + (-Ug)o = initial energies = Kf + (-Ug)f = final energies = ½ $m(vo)^2$ + (-GmM)/ro = ½ $m(vf)^2$ + (-GmM)/rf , and then canceling the "m" values = $(v0)^2/2$ + (-GM) /ro = $(vf)^2$ /2 + (-GM)/rf where rf = 1.1 AU; r0 = 2.7 AU; vf = 35.39 km/s and vo = 17.2 km/s.

$\sum$ Energies = $(17.2)^2/2$ + (-13.28 x 10^{10} /1.496 x 10^8) / 2.7 = (35.39)2/2 + (-13.28 x 10^{10} / 1.496 x 10^8)/ 1.1 = 148 + (-889)/2.7 = 626 + (-889) / 1.1 = 148 – 330 = -182 = 626 - 808 and re-inserting the value of the mass of Earth into both sides of the equation where m = 5.97 x 10^{24} kg to obtain the units of energy.

Ko = (5.97 x 10^{24} kg) (148) km^2/s^2 = 884 kg km^2/s^2 = initial kinetic energy.
(-Ug)o = (5.97 x 10^{24} kg) (330) km^2/s^2 = 1970 kg km^2/s^2 = initial potential energy.
Kf = (5.97 x 10^{24} kg)(626) km^2/s^2 = 3737 kg km^2/s^2 = final kinetic energy.
(-Ug)f = (5.97 x 10^{24} kg)(808) km^2/s^2 = 4823 kg km^2/s^2 = final potential energy.

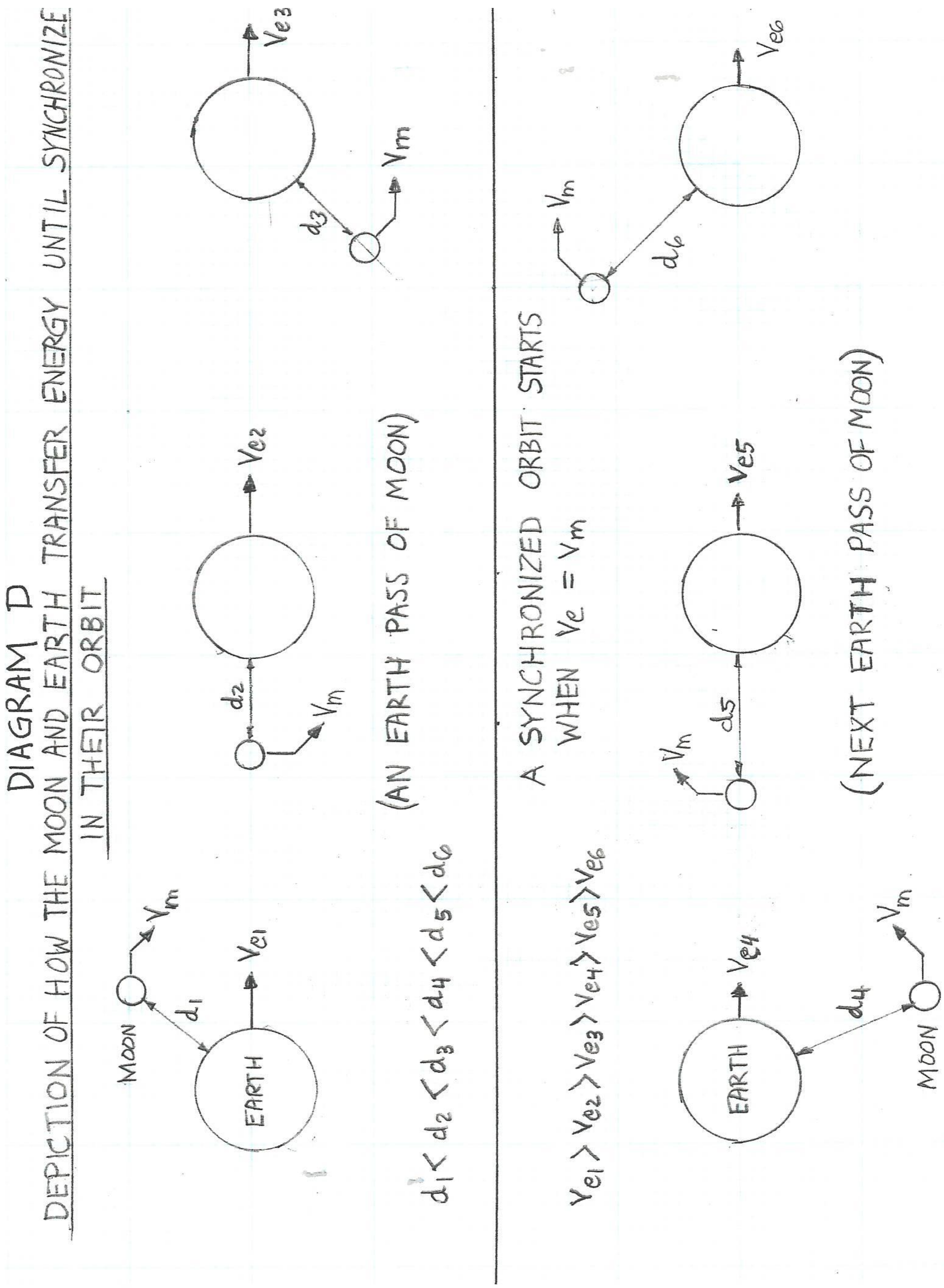
$\sum$ Energies = Ko + (-Ug)o = 884 -1970 = Kf + (-Ug)f = 3737 – 4823 = -1086 kg km^2/s^2

The initial and final values are equal and do indicate conservation of energy. But this single equation does not properly integrate the constantly changing kinetic energy, ½ mv^2, and potential energy, (G m M)/ r. The previous set of equations calculated the changes at various positions in the trajectory over smaller units of time thereby integrating better the changing energies as the Earth spiraled toward the Moon's orbit.

The initial velocity of 17.2 km/s of impacted Earth that was previously computed is critical in determining the final velocity as the Earth enters the Moon's orbital region. If this initial velocity is less, then, of course, the Earth's initial velocity passing the Moon is less. For the rogue planet hitting the Earth at a more oblique angle toward its orbital motion leads to less initial velocity – such as a 45^0 angle producing a velocity of 16.6 km/s and a 30^0 angle producing a velocity of 16.2 km/s.

The striking 90^0 angle of the rogue planet generates 17.2 km/s and produces a better trajectory of the Earth toward the solar system's center; however, the initial passing velocity of the Earth produces a larger difference between the Moon's orbital velocity of 30 km/s. Overall, a good approximation for Earth finding the Moon's orbit after displacement from an orbit between Mars and Jupiter took place. The next topic will explore how the Moon slows the Earth's orbital velocity at one AU orbital radius to match the Moon's orbital velocity and allow synchronization of the two bodies.

11. How the Moon and Earth Transfer Energy



12. Calculating the Energies Transferred Between the Earth and Moon

It is assumed that the Earth entered the Moon's orbital region at a velocity closer to the orbital velocity of vc = 30 km/s than to the escape velocity of 42.1 km/s. A previous series of calculations indicate a possible initial velocity of 35.4 km/s. For this calculation, Earth's initial orbital velocity, vo = 35 km/s, is chosen. The following calculation shows how a possible initial close encounter with the two passing bodies decreases the Earth's velocity from 35 km/s to 30 km/s by repeated impulse momentum events created by the rapidly changing gravitational forces between the two bodies as one passes the other.

This calculation attempts to show how the transfer of energies with the Moon caused the Earth over a long period to slow down and match the velocity of the Moon. The primary angular momentum change to the Moon is the effect of the Moon orbiting or weaving about Earth 12 times for each orbit around the Sun.

Angular momentum changes occur due to the rotational changes of both the Moon and Earth through tidal forces. These comparatively much smaller amounts of angular momentum change likely offset each other and are neglected in the next calculation.

However, when the two bodies become synchronized orbiting together at 30 km/s, these tidal forces become important for slowing the rotational velocities and eventually tidal locking one side of the Moon toward the Earth. Another energy conservation equation will then compute values in a second calculation for another important energy transfer after the synchronization process starts.

The first calculation begins with an important assumption of the Earth's capture being aided by a close encounter with the Moon when it entered the Moon's orbital region. This central assumption will start with 90,000 km = rm for this close encounter, which remains mostly the same for all of Earth's passings until synchronization occurs after the Earth slows down to match the Moon's orbital velocity.

The following data, equations, and assumptions are listed and will be applied to the calculation:
^ mM = Moon's mass = 7.3×10^{22} kg;
^ mE = Earth's mass = 5.97×10^{24} kg;

^ vIM = Initial Moon's velocity during one passing of the Earth;
^ vFM = Final Moon's velocity during one passing of the Earth;
^ vIE = Initial Earth's velocity during one passing;
^ vFE = Final Earth's velocity during one passing;
^ 1 AU = approx. orbital radius of Moon = 1.496×10^8 km;
^ 1 yr. = 31.5×10^6 s (present time for one orbit of Earth);
^ ΔMM = momentum change of Moon due to Earth's gravity force = mM (vFM - vIM);
^ ΔME = momentum change of Earth due to Moon's gravity force = mE(vIE – vFE);
^ rM = assumed close encounter distance between Moon and Earth = 90,000 km;
^ vo = orbital velocity ≈ √ (GMsun/orbital radius)= √ (13.28×10^{10} /ro);
^ roH = Moon's higher orbital radius = 149,597,871 km + 90,000 km = 149, 687,871 km;
^ roL = Moon's lower orbital radius = 149,597,871 km - 90,000 km = 149, 507,871 km;
^ voH = Moon's higher orbital radius velocity = √(13.28×10^{10}/149,687,871) = 29.77434 km/s;
^ voL = Moon's lower orbital radius velocity = √(13.28×10^{10}/149,507,871) = 29.79226 km/s;
^ Δv0 = Moon's change in velocity when changing orbits = voL - voH = 0.01792 km/s

Assume that the Earth is captured in an elliptical orbit with a semi-major axis and semi-minor axis similar to present-day values. The semi-minor axis is close to within an assumed value of 90,000 km from the Moon's orbital radius. The difference between the semi-major and semi-minor axes is about 5×10^6 km. Hence, only when Earth passes the Moon with a sufficient close-encounter distance do the gravity forces interact to change the Moon's orbit either from an upper to a lower orbit or from a lower to an upper orbit. It is difficult to determine the number of orbits that are taken for a certain number of close encounters due to the elliptical property of both bodies. However, the number of close encounters can be determined that will match the Earth's velocity with the Moon's at 30 km/s.

Henceforth, momentum change is conserved between the two bodies and ΔMMOON = ΔMEARTH and:

^ ΔMM = mM x Δv0 = 7.3 x 10^{22} kg x 0.01792 km/s = 0.1308 x 10^{22} kg km/s.
^ ΔME = mE x ΔvE = mE (vIE – vFE).
^ ΔvE = ΔMM/mE = (0.1308 x 10^{22} kg km/s) / 5.97 x 10^{24} kg = 0.000219 km/s = Earth's change or reduction in velocity for **each** close-encounter-type pass between the Earth and Moon.

Now the number of times the Earth has close-encounter passes with the Moon to slow it from 35 km/s to 30 km/s can be determined.

The number of Earth passes = (35km/s – 30km/s)/ ΔvE = (5 km/s)/ (0.000219 km/s) = 22,830 times. The number of years to achieve synchronization is well over 22,830 orbits. This value depends a lot on the initial elliptical orbit parameters of the Moon. If the Moon's orbit had a similar eccentricity, then 22,830 close-encounters will happen quickly. Otherwise, it may take 10x to 100x more orbits. Nevertheless, synchronization or matching of orbital velocities will eventually occur relatively fast compared with the age of the Earth.

In conclusion, the transfer of momentum between the Moon in its established orbit and the faster passing Earth is dependent upon the mass difference between the two bodies, the Sun's gravity, the close-encounter distance, the orbital parameters, and the Earth's initial velocity vector leaving its original orbit between Mars and Jupiter. The main variables or parameters are the close-encounter distance of 90,000 km and the Earth's initial orbital velocity of 35 km/s produced by a very rough computational analysis. These assumed parameters yield about 23,000 close-encounter passings by the conservation of momentum method for the Moon and Earth to become synchronized at the same orbital velocity of 30 km/s. At the point of synchronization, the Moon begins to follow the elliptical orbit of the Earth, the much more massive body, using a wavelike trajectory around the Sun.

A second calculation analyzes what occurs within the Earth-Moon system almost immediately after synchronization occurs. Both the Earth's and Moon's rotations begin to slow down by the immense changing of tidal forces caused by the varying gravity forces on their surfaces as they spin. These forces are estimated to cause 1000 meter tides and hurricane winds, which thoroughly mix the oceans with the rocky surfaces of the newly formed continents. The tidal forces also cause increased earthquakes, volcanism, and tectonic plate movements. Conditions for normal life forms are unlikely until the two bodies separate enough to reduce tidal acceleration forces for a more livable condition. The calculation will estimate how many years are needed to arrive at present-day conditions from the conditions around 3 billion years ago when the origins of life started and about 2.8 billion years ago when multi-cell animals emerged on Earth's surface.

More very basic assumptions are needed to start this next calculation. The original rotation of the Moon assumes 24 hours per day, which is comparable to present-day Mars. Some studies in the past ten years have estimated that the Earth rotated every 6 hours. Of course, Earth's present complete rotation is 24 hours, and the Moon's rotation is greatly reduced to 12 times every year, considered as virtually zero spins.

The following data, equations, and assumptions are listed and are applied to the second calculation set:

IEM = the moment of inertia of the Moon and Earth about the Earth's axis = IE + mM x h^2

Where:

^ h = approximate perpendicular distance between the two parallel axes through the centers of gravity of the Moon and Earth = present distance between Moon and Earth ≈ 384,400 km.
^ hF = 384,000 km.
^ hI = 90,000 km.
^ mM = total mass of body = Moon's mass = 7.3 x 10^{22} kg.
^ mE = total mass of body = Earth's mass = 5.97 x 10^{24} kg.
^ IE = moment of inertia about the axis through the center of mass for Earth = 2/5 mE x rE^2 for a sphere where -
^ rE = Earth's mean radius = 6371 km.
^ IE = Earth's moment of inertia = 2/5 (5.97 x 10^{24} kg) x $(6371 \text{ km})^2$ = 9.69 x 10^{31} kg km^2.
^ IM = moment of inertia about the axis through the center of mass for Moon = 2/5 (7.3 x 10^{22} kg) x $(1737 \text{ km})^2$ = 8.81 x 10^{28} kg km^2.
^ mM x h^2 = (7.3 x 10^{22} kg) x $(384{,}400 \text{ km})^2$ = 1.08 x 10^{34} kg km^2 .

Hence:

^ IEM = 9.69×10^{31} kg km^2 + 1080 x 10^{31} kg km^2 ≈ 1090×10^{31} kg km^2
^ ωEF = 2π radians/one day = 6.28 rad/86,400 s =7.27×10^{-5} radians/second = 0.727×10^{-4} radians/s = present angular angular rotational velocity of Earth.
^ ωEI = initial angular rotational velocity of Earth = 2π radians/6 hour-day proposed for the Giant Impact Hypothesis which is too fast = 6.28 rad/21,600 s = 2.91×10^{-4} radians/s = 29.10×10^{-5} radians/s. (ωEI = to be re-determined.)
^ ωMF ≈ 0 = final angular rotational velocity of the Moon.
^ ωMI = initial angular rotational velocity of Moon ≈ ωEF = 0.727×10^{-4} radians/second = 0.727×10^{-4}.
^ ωEM = angular orbiting velocity of Moon ≈ 1 revolution / 27.3 days = (2π radians)/ (27.3 x 24 x 60 x 60 seconds) = 0.0266×10^{-4} radians/s

Applying the conservation of kinetic energy of rotation:

Kinetic energy of rotation = ½ I x ω^2 , where I = moment of inertia and ω = angular speed.

∑EI = sum of all initial rotational energy and potential energy in the Earth-Moon system = ½ IE x ωEI^2 + ½ IM x ωMI^2 + (G x mE x mM)/ hI

∑EF = sum of all final rotational energy and potential energy in the Earth-Moon system = ½ IE x ωEF^2 + ½ IM x ωEM^2 + ½ IEM x ωEM + (G x mE x mM)/ hF

½ IE x ωEI^2 = initial K.E. of rotation for the Earth = ½ (9.69×10^{31} kg km^2) (2.91×10^{-4} rad/s)^2 = 4.10×10^{24} kg km^2/s^2

½ IE x ωEF^2= final K.E. of rotation for the Earth = ½ (9.69×10^{31} kg km^2) x (7.27×10^{-5} rad/s)^2 = 0 .2561 x 10^{24} kg km^2/s^2

½ IM x ωMI^2 = initial K.E. of rotation for the Moon = ½ (8.81×10^{28} kg km^2) x (7.27×10^{-5} rad/s)^2 = 0.000232×10^{24} kg km^2/s^2

½ IM x ωMF^2 = final K.E. of rotation for the Moon = 0

The potential energy loss by the Moon moving away from the Earth is actually determined by the Sun's gravity field or the gravity force between the Sun and Moon. The Moon is the only satellite in the solar system that is held in its orbit by the Sun and not its parent planet.

^ Msun = 1.99 x 10^{30} kg = mass of the Sun.
^ G x mM x Msun = (6.674 x 10^{-20} $km^3 kg^{-1} sec^{-2}$) x (7.34 x 10^{22} kg) x (1.99 x 10^{30} kg) = 9.75 x 10^{33} km^3 kg s^{-2}

(G x mM x Msun / hI) = (9.75 x 10^{33} km^3 kg s^{-2}) / (149,600,000 + 90,000) km = 9.75 x 10^{33} km^3kg s^{-2} /149,690,000 km = 65.13 x 10^{24} km^2 kg s^{-2}

(G x mM x Msun / hF) = (9.75 x 10^{33} km^3 kg s^{-2}) / (149,600,000 + 384,400) km = 9.75 x 10^{33} km^3kg s^{-2} /149,984,000 km = 65.00 x 10^{24} km^2 kg s^{-2}

The term, (½ IEM x ωEM) , drops away since this kinetic energy of the orbiting Moon already is accounted since the impulse momentum of the faster orbiting Earth created the Moon's orbit when synchronization occurred. The energies are now added and balanced to solve for the unknown value of the initial Earth's rotation found in the term, (½ IE x $ωEI^2$).

∑ Energies = (½ IE x $ωEI^2$) + ½ IM x $ωMI^2$ + (-G x mM x Msun / hI)
= ½ IE x $ωEF^2$ + (G x mM x Msun / hF)
= (½ IE x $ωEI^2$) + 0.000232 x 10^{24} + (-65.13 x 10^{24}) = 0.2561 x 10^{24} + (-65.00 x 10^{24}).

(½ IE x $ωEI^2$) = - 0.000232 x 10^{24} + 65.13 x 10^{24} + 0.2561 x 10^{24} – 65.00 x 10^{24} = 0.3859 x 10^{24} km^2 kg s^{-2}

ωEI = √(2 x 0.3859 x 10^{24} km^2 kg s^{-2} / 9.69 x 10^{31} kg km^2) = √(0.790 x 10^{-8} radians /s) = 0.889 x 10^{-4}radians /s

time / 1 rev = (2π radians) / (0.889 x 10^{-4} radians /s) = 70,641 seconds

The Earth's initial rotation after finding its new orbit is computed to be 70,641 s /3600 s /hour = 19.6 hours. After the Earth became synchronized with the Moon the Earth's rotation gradually slowed to its present 24 hours per rotation. The Moon's rotation stopped probably rather quickly within thousands of years to become tidally locked with the Earth, because the Moon's kinetic energy of rotation from the computations is a very small fraction of the other energy transfers that are involved.

This rotational speed has good agreement with other known spin speeds in the solar system. Mars' rotation period is 24.6 hours. The outer planets with their larger masses would reasonably have faster rotational periods ranging from 9.8 to 17.4 hours. When Earth was in its original orbit, it more than likely had a slightly faster rotational period until its major impact with a rogue planet occurred. Mercury's and Venus's almost non-existent rotational periods are the results of the combination of partial tidal locking with the Sun and large impacts.

NASA's favored controversial Giant Impact Hypothesis requires a very fast rotational period for the young Earth of 5 to 6 hours. This model proposes a large Martian-size body struck Earth with a glancing blow to gain enough angular momentum for the impact debris to achieve orbital velocity and accrete into an orbiting Moon. Unfortunately, this type of impact and the required angular momentum of the Moon creates a very high and inappropriate rotational period for the Earth. This accelerating spin-up would have torn the planet apart. In the EMM hypothesis, the Earth collides almost head-on, but at an oblique angle to the equator. This type of inelastic collision absorbed most of the Impactor's mass and contributed to the axial tilt and orbital displacement. This type of collision would have a much smaller effect on the existing rotational period. The previous calculation that results in 19.6 hours for one rotation produces the condition for the planet to slow down after exchanging energies with the Moon. This value supports very well the EMM hypothesis and other existing parameters of our current solar system.

Respected scientific studies proposed that a day in the Devonian geological period occurring 419 to 360 million years ago was 2.2 hours less. In a later period, the Pennsylvanian of 358 to 298 million years ago, the day length was about 22.4 hours. The geological and paleontological evidence that the Earth rotated faster in the remote past is well supported, but this hypothesis seriously questions the amount of slowing of the rotation. If the Earth's spin were continually decaying for the past 3.8 billion years at the rates purported for the above geological periods, then the Earth would have almost stopped spinning a long time ago.

Other more believable data collected from astronomical studies indicate that the Moon is receding approximately 38 mm per year. As the system's kinetic energy of rotation decreases, the potential energy between the Moon and Earth also decreases. The Earth's rotation is slowing approximately 2 seconds for every 100,000 years based on the previous geological data. These phenomena are due to the land and ocean tides raised by the Moon, called tidal acceleration; those forces collectively reduce the Earth's rotation. These rates of receding and rotational period reduction presumably were in effect about 3.8 bya since the Moon began orbiting the Earth.

Hence, the total distance for receding is –

dtotal = (38 mm/yr) x 1 km/10^6 mm x 3.8 x 10^9 yr = 144,400 km

Δd = the present distance of (384,400 km) – the initial close-encounter distance of (90,000 km) - 144,400 km = 150,000 km

Δd = 150,000 km of separation distance that is not yet explained. There must be a reason for this unexplained separation distance.

Now let's assume the Earth has been slowing down 2 seconds every 100,000 years for the past 3.8 billion years, then the total amount of seconds since that time is –

Δt = (2 s / 100,000 yrs) x 3.8 x 10^9 years = 76,000 seconds or = 76,000 s x 1 hr /3600 s = 21.1 hours which is considered impossible.

The Earth should not be super-spinning at a (24 hr – 21.1 hr) = 2.9 hour rotational period; this spin speed is much too fast. This data of 2s /100,000 years is based on geological evidence of the Devonian Period that occurred 420 mya. Hence,

ΔtDevonion = (2 s / 100,000 yrs) x 420 x 10^6 years = 8400 seconds = 2.33 hours

As already mentioned, this geological and paleontological data is questionable. The Earth cannot sustain a slowing rate of (2 s / 100,000 years) for 3.8 billion years unless its starting rotation period is about 2.9 hours. This superfast rotation rate would almost produce an oblate object like a hockey puck. There is no experience of such an object in our solar system.

However, it is difficult to refute the unexplained separation distance of 150,000 km. Why did not the Earth and Moon keep moving away from each other over the entire period after becoming synchronized? How did this discrepancy occur? The rate of separation should have been even higher in the initial stages when the Moon was much closer. Let's examine a possible process that caused this extra 150,000 km of separation. The synchronization event is re-visited.

The Earth has been passing the Moon each time, pulling the Moon between either a lower or upper orbit. Eventually, the Earth velocity reduces to the same orbital velocity as the Moon. During a very short time, the Moon begins orbiting the Earth. The force of gravity between the two bodies now causes the Moon to fall toward the Earth. The Moon must now gain kinetic energy of rotation to both orbit the Earth and keep orbiting the Sun along with the Earth. The process is comparable to twirling a stone on the end of a string. The more rotational energy given to the string, the more the stone rises into a larger diameter orbit with faster velocity.

The Moon did not originally have an orbital velocity around Earth except for a slightly increased velocity when it was changing orbits while orbiting the Sun. Now the Moon adds a vector to its overall velocity to orbit the Earth and now stay in its vicinity. This orbital velocity is currently 1.022 km/s. The radians/s of this orbit is Ш = orbital velocity /orbital radius = (1.022 km/s) / 384,000 km = 2.66 x 10^{-6} rad/s. The average orbital velocity assumes that (0 + 1) /2 = 0.5 km/s when the Moon was moving outward from its initial distance from the Earth at 90,000 km. Hence, the following third calculation of computations and assumptions follow:

The distance the Moon moved outward while generating its orbit around the Earth is assumed to be the questionable 150,000 km mentioned previously. Its final orbital radius after synchronization is assumed to be –

h_f = 90,000 + 150,000 = 240,000 km, and of course the existing orbital radius is

h_e = 90,000 + 150,000 + 144,400 = 384,400 km where the 144,400 value represents the unrelenting 38 mm/year that the Moon is moving away from Earth for the past 3.8 billion years assuming an approximate constant rate.

vM avg ≈ 0.5 km/s during Moon's displacement from 90,000 to 240,000 km/s.

$Ш_f$ = average final radians/s of Moon's orbit around Earth = vM avg /h_f = (0.5 km/s) / (240,000 km) = 2.083 x 10^{-6} rad/s

$K.E._{ri}$ = initial kinetic energy of orbiting Moon did not exist = 0

$K.E._{rf}$ = average final kinetic energy of orbiting for the Moon and Earth rotating around the Earth's axis after the Moon attains an orbital radius of 240,000 km. = ½ (IE + mM x hf2) $(Ш_f)^2$ = ½ [9.69 x 10^{31} kg km^2 + 7.3 x 10^{22} kg x $(240,000\ km)^2$] x

$(2.083 \times 10^{-6}$ rad/s$)^2 = ½ [430.19 \times 10^{31}] \times (4.339 \times 10^{-12}) = 933.3 \times 10^{19} = 0.933 \times 10^{22}$ kg km^2/s^2

$P.E._i$ = initial potential energy between the Earth and Moon = G x mM x mE / h_i = $(6.674 \times 10^{-20} \times 7.34 \times 10^{22} \times 5.97 \times 10^{24})$ / 90,000 km = $(292.5 \times 10^{26}$ km^3 kg/s^2) / 90,000 km = 32.50×10^{22} kg km^2/s^2

$P.E._f$ = final potential energy between the Earth and Moon = G x mM x mE / hf = $(292.5 \times 10^{26}$ km^3 kg/s^2) / 240,000 km = 12.19×10^{22} kg km^2/s^2

$K.E._{rf}$ (total) = factor M x 0.933×10^{22} kg km^2/s^2 = $P.E._i$ - $P.E._f$ = 32.50×10^{22} - 12.19×10^{22} = 20.31×10^{22} kg km^2/s^2

Factor M = 20.31×10^{22} / 0.933×10^{22} = 21.76 where “Factor M” represents the approximate number of total orbits of the Moon required to achieve an energy balance due to the gravity force and given motions based on a simple averaging method.

In other words, the Moon spiraled outward for about 22 orbits before acquiring a stable orbit around the Earth - almost immediately after the Earth eventually slowed within a close range of 30 km/s and was traveling parallel at 90,000 km from the Moon. This outward motion covered about 150,000 km in about two years. At this location of 240,000 km, the Moon slowly recedes over the next 3.8 billion years at 38 mm/year to cover an additional separation distance of 144,400 km due to steady tidal accelerations between the two bodies. Currently, at 384,400 km away from Earth, the Moon continues to move out every year as the Earth very slowly reduces its rotational period. The measurement of Earth’s reduction rate of rotational period is very much in question by consensus science.

Now a total scenario or timeline can be created to outline the Earth-Moon system capture mode and synchronization process from the time the Earth moved into the Moon’s primordial orbit 3.8 billion years ago to the present time.

13. Summary and Timeline for the Earth-Moon Capture

Event	10^9 yrs ago	Distance Apart - km	Moon's/Earth's Velocity – km/s	Earth's Rotation	Moon's Rotation	Milestones
Earth enters Moon's orbital region	3.9	90,000	30 / 35	19.6 hrs	24 hrs	Earth's land surface red hot; oceans are boiling.
Earth slows to match Moon's orbital velocity. Synchronicity begins.	Took greater than 23,000 close-encounters or orbits.	90,000	30 / 30	19.6 hrs	24 hrs	Earth cooled, but has active volcanism and tectonics.
Moon begins to orbit the Earth and spirals outward.	Approx. 22 Moon-accelerated orbits	90,000 + 150,000 = 240,000	30 / 30 (Moon begins to orbit Earth and move away very quickly.	19.6 hrs	24 hrs	Severe tides: hurricane winds and 1000 meter ocean tides.
Steady tidal acceleration. occur between Earth & Moon; Moon's mares begin to solidify.	3.9 to 3.0	270,000	30 / 30 (Moon begins to orbit at 1.022 km/s)		<<24 hrs	Collisional debris(asteroids) mostly swept away; bacterial life starts
Moon becomes tidally locked.	2.9 to 2.7	278,000	30 / 30 (Moon orbits at 1.022 km/s)	> 20 hrs	≈ 0 hrs	Multi-cellular animals appear due to more peaceful surface

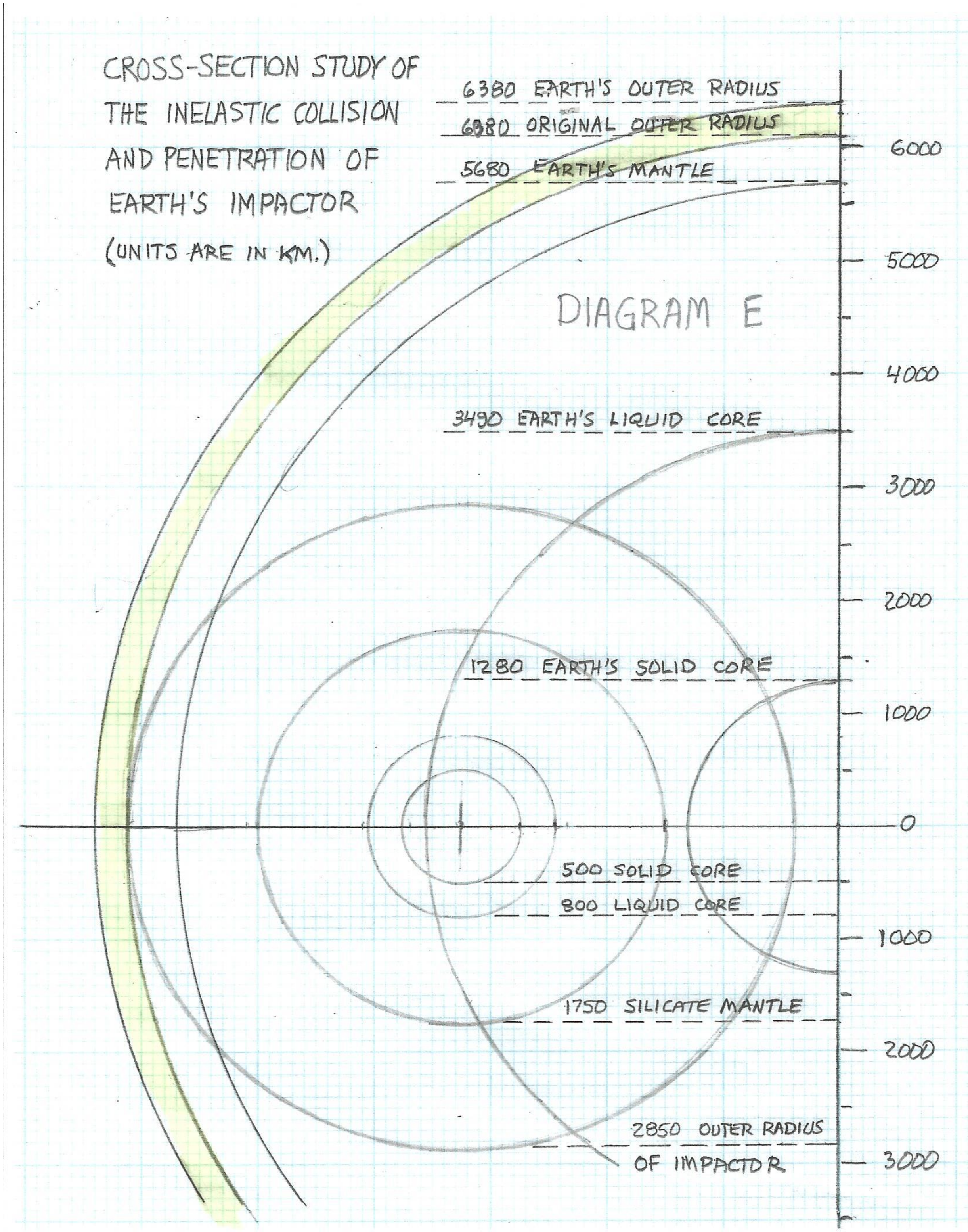
Present time	0	384,400	30 / 30 (Moon orbits at 1.022 km/s)	24 hrs (spin gradually slowing)	0 hrs. (27.3-day Earth orbit	Moon receding @ 38 mm/yr from 278,000 km distance onward.

The values for Earth slowing from 35 to 30 km/s; and for the Moon moving outward by 294,400 km; and for the Moon to become synchronized with Earth after orbiting greater than 23,000 times or approximate years; and for the Earth's original rotation of 19.6 hours are all reasonable values. This scenario provides the angular momentum for the Moon orbiting Earth and why the Moon acts more like a planet instead of a planetary satellite. No current models can provide this necessary angular momentum for the Moon and an adequate capture mode except for the Earth's Metamorphosis (EMM) hypothesis with both its collision and capture modes.

14. Penetration of the Impactor with Earth

Now I will consider all the possible events that can occur after the Impactor ices gorge the Earth's crust and mantle. The postulated cross-sections of the two bodies are shown. And the amount of expansion of the cracked crust or the Earth's bloated state is also shown.

Drawing of Cross-Sections of the Earth and Rogue Planet Impactor Showing Approximate Expansion of Crust and Mantle after Collision in Yellow



The moon, Ganymede, is the guide for determining the assumed cross-section of the Impactor body. This moon has a mean radius of 2634 km (0.413 Earths) and a volume of 7.6 x 10^{10} km^3 (0.0704 Earths). Ganymede has a rigid ice crust with an outer ice mantle 800 to 1000 km thick and an inner silicate with a 950 to 1150 km thickness. The iron sulfide and iron core have a solid portion 500 km radius and a liquid portion of an 800 km radius.

The Impactor's assumed mean radius is 2880 km, with a volume of 10.0 x 10^{10} km^3. Hence, the Impactor/Ganymede ratio is 2880/2634 = 1.093. The core structure of the two bodies remains the same. The ratio applies to the inner and outer mantle radii.

The data for the Earth is 6378 km for the mean radius with a volume = 1.083 x 10^{12} km^3. The solid core is a 1280 km radius, the liquid portion of the core is a 3490 km radius, and the mantle is a 5680 km radius. What remains is a 700 km thickness that includes the lithosphere with the crust and the asthenosphere.

The resulting increase in the Earth's radius after impact includes the lithosphere that comprises the tectonic plates, a large portion of the asthenosphere, and a lower viscosity and highly ductile layer on which the lithosphere rides. The mixing of the ice and silicate mantles of the Impactor created this asthenosphere layer. The ices and silicates of the Impactor differentiated and collected under the already existing lithosphere and created a less viscous material forming on top of the upper mantle, called the Moho, that aids in the movement of the tectonic plates.

The cross-section study reveals that the Impactor might have reached the Earth's core. More than likely, the spheroid was compressed and flattened and probably only penetrated ½ of the liquid core. The iron and iron sulfides of the Impactor's core would eventually sink and combine with the Earth's core. A mixture of the Impactor's icy and silicate mantles and the Earth's silicate mantle ejected onto the surrounding oceanic crust. These mantle materials also oozed from the center of the vast crater to fill the void of the crater. The Earth's original continent formed this way. The materials of this continent are less dense than the original crust and any future oceanic crusts because the Earth's mantle is chemically combined with lighter elements and compounds of the Impactor's ices and silicate mantles.

The solidified continental crust material would forever remain less dense than the oceanic crusts. The oceanic crusts develop from the rise and cooling of the Earth's original mantle materials, which are denser and increase in density through a thermal contraction. Any movements of the oceanic plates against the continental plates will subduct and always go under the lighter continental crusts, thereby preserving cratons of original rock near the centers of most continents that were part of the first supercontinent. These cratons solidified 3.9 to 3.5 billion years ago after the first continent rose from the crater of Earth's Impactor to mark the time of impact.

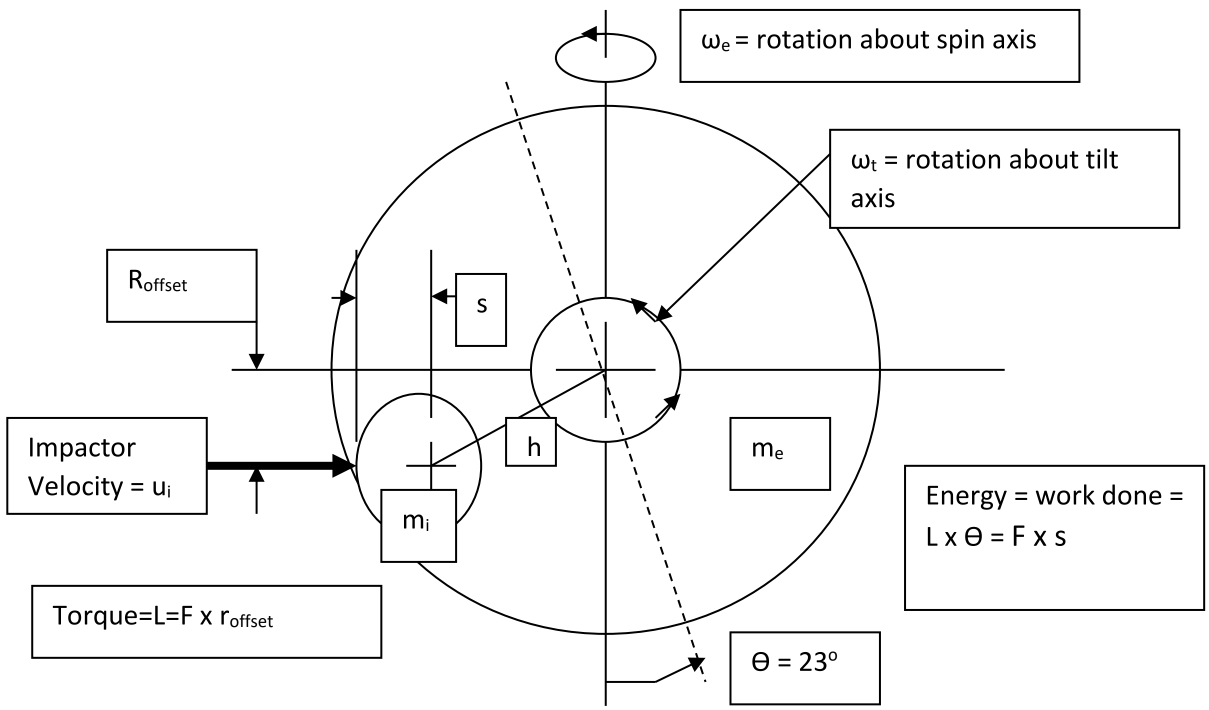
Many of the more volatile materials such as CO_2, H_2O, and CH_4 from the Impactor would disperse throughout the Earth's very molten mantle, eventually differentiate, and rise to the Earth's surface only to be trapped underneath by the existing hardened oceanic crust and newly crystallized continental crust. These trapped pockets of volatiles would then create migrating hot spots that would continue to present times to cause volcanic eruptions not related to subduction zones.

Further proof of the creation of the first supercontinent on Earth is the distinctively different compositions of the most abundant compounds found in the oceanic and continental crusts. From computations based on 1672 analyses of all kinds of rocks, a geochemist, F.W. Clark, deduced that 99.22% were composed of 11 oxides. Another book, *The Inaccessible Earth*, by Geoff C. Brown and Alan E. Mussett, compared the percentages of these oxides with both continental and oceanic crusts. These percentages were consistently different for each type of crust, proving that the differentiation of these molten materials came from two different sources. Those sources were the mantles of the Earth and its major Impactor of 3.9 billion years ago.

15. Conservation of Energy Before and After the Collision

Our primary interest in this conservation of energy during the collision stems from what rotational kinetic energy possibly remains after considering the "before" and "after" linear kinetic energies of the collision. This delta rotational kinetic energy is then applied to cause the Earth's spin axis to tilt. An assumption makes the angle of impact approximately perpendicular to the Earth's orbital velocity. Then any change to the rotational spin velocity is neglected; any remaining energy necessary to balance the conservation of energy goes into only rotating the spin axis perpendicular to its direction, thus causing the Earth's tilt. See the following diagram.

Creation of Torque to Tilt the Earth's Spin Axis



Consider now the balancing of kinetic energies before and after collision:

$K_{initial}$ = ½ $m_e u_e^2$ + ½ $m_i u_i^2$ = initial kinetic energies

K_{rot} = ½ $I_f \omega_t$ kg km^2 (rad/s)^2 = final kinetic energy of rotation

K_{lin} = ½ (m_e + m_i) v_R^2 kg km^2/s^2 = final linear kinetic energy

K_{final} = K_{rot} + K_{lin} = ½ (m_e + m_i) v_R^2 + ½ $I_f \omega_t^2$ = final kinetic energies

Hence the energy of conservation produces:

$$\tfrac{1}{2} m_e u_e^2 + \tfrac{1}{2} m_i u_i^2 = \tfrac{1}{2} (m_e + m_i) v_R^2 + \tfrac{1}{2} I_f \omega_t^2$$

Where the individual values are:

ω_t = the average angular velocity (rad/s) to be determined .
m_e = initial Earth's mass = 5.72 x 10^{24} kg.
m_i = Impactor mass = 0.25 x 10^{24} kg.
u_e = initial orbital velocity of Earth = 18.5 km/s
u_i = initial velocity of Impactor normal to spin axis of Earth = 45 km/s.
$m_e + m_i$ = 5.72 x 10^{24} + 0.25 x 10^{24} = 5.97 x 10^{24} kg.
v_R = resultant velocity of combined Earth and Impactor = 17.2 km/s.

Note: This computed resultant velocity has already accounted for energy losses due to heat, noise, light, dispersion of debris, and reductions in both bodies' spin created during the collision. The assumed value of 10% is one of the larger questions of this model but is probably of the right scale, considering that the Earth's orbit and tilt are affected.

I_f = final moment of inertia after Impactor is imbedded inside Earth's mantle.
$I_f = I_e + I_i$ = moment of inertia of Earth assuming perfect sphere and constant density + moment of inertia of Impactor about the center of the Earth's axis.

$I_f = 2/5\, m_e r_e^2 + (m_i r_i^2 + m_i h^2)$ where h = perpendicular distance between two parallel axes of the two center of gravities and –

R_e = 6380 km = radius of Earth;

R_i = 2850 km = radius of Impactor

Set-
h = 3500 km (see the previous Diagram) = approximate distance of center of imbedded Impactor from the center of the Earth

$K_{initial}$ = ½ (5.72 x 10^{24} kg) x (18.5 km/s)^2 + 1/2 (0.25 x 10^{24} kg) x (45 km/s)^2 = 978.8 x 10^{24} kg km^2/s^2 + 253.1 x 10^{24} kg km^2/s^2 = 1232 x 10^{24} kg km^2/s^2

K_{final} = ½ (5.97 x 10^{24} kg) x (17.2 km/s)^2 + ½ [2/5 (5.72 x 10^{24} kg) x (6380 km)^2 + (0.25 x 10^{24} kg) x (2850 km)^2 + (0.25 x 10^{24} kg) x (3500 km)^2] x [ω_t^2] = (883.1 x 10^{24} kg km^2/s^2) + ½ [9.31 x 10^{31} kg km^2 + 0.20 x 10^{31} kg km^2 + 0.31 x 10^{31} kg km^2] x [ω_t^2] = 883.1 x 10^{24} kg km^2/s^2 + [4.91 x 10^{31} kg km^2] x [ω_t^2]

And then:

K_{rot} = 4.91 x 10^{31} kgkm^2 x [ω_t^2] and
K_{lin} = 883.1 x 10^{24} kg km^2/s^2
$K_{initial}$ = K_{final} = 1232 x 10^{24} kg km^2/s^2 = 883.1 x 10^{24} kg km^2/s^2 + [4.91 x 10^{31} kg km^2] x [ω_t^2] , and solving for ω_t

ω_t = √ [(1232 x 10^{24} kg km^2/s^2 - 883.1 x10^{24} kg km^2/s^2) / (4.91 x 10^{31} kg km^2)] =
ω_t = √ [(349 x 10^{24} kg km^2/s^2) / (4.91 x 10^{31} kg km^2)] = √ [7.1 x 10^{-6} (radians/sec)^2] =

ω_t = 2.66 x 10^{-3} radians/sec = rotation velocity about the tilt axis = Θ/t.

Θ = radians of rotation = 23^0 of tilt x 2π/360^0 = 0.401 radians

t = Θ/ω_t = 0.401 radians / 0.00266 radians /s = 152s = 2.5 minutes -

This is very fast; the time for the Impactor to break through the lithosphere and penetrate the mantle and become compressed is not included, nor is additional time for angular impulse considered.

I_f = (9.31 + 0.20 + 0.31) x 10^{31} kg km^2/s^2 = 9.82 x 10^{31} kg km^2/s^2

K_{rot} = ½ I_f x ω_t^2 = ½ (9.82 x 10^{31} kg km^2) x (2.66 x 10^{-3} radians/s)^2 ≈
K_{rot} = 347 x 10^{24} kg km^2 /s)^2
K_f = K_{lin} + K_{rot} = 883.1 x 10^{24} kg km^2/s^2 + 347 x 10^{24} kg km^2 /s^2 = 1230 kg km^2/s^2.

The computed kinetic rotational energy generated by the collision is now applied to tilting the Earth.

16. The Calculation for the Tilt of Earth's Spin Axis

Now the necessary parameters are available for calculating the possible amount of tilt of the Earth's spin axis caused by the impact. Some new assumptions are presented. See the previous diagram. The Impactor's approach is selected for an offset of r_{offset} = 3000 km south of the Earth's equator. The amount of work available to create the force acting on Earth's mass equals the total kinetic linear energy available or 883 x 10^{24} kg km^2/s^2 determined from the previous section. This rapidly changing force and torque act over a certain distance that resists penetrating the Earth's mass. This distance is set at s = 1200 km for the first large decrease in velocity since the remaining motion energy for the Impactor to penetrate the Earth goes into the compression and sideways dispersal of the Impactor's materials inside the Earth's mantle. The energy also goes into expanding the mean average of the Earth's radius to about 300 km, thereby creating the various plates in the Earth's crust. Hence, further speed reductions are estimated in steps to portray the varying or differential rate of rapid de-acceleration in realistic terms. The total distance of penetration assumes 5200 km, which in reality is a combination of penetrations of the Earth's mantle and the compression of both the Impactor and the Earth's mantle. The work to tilt the Earth divides into two parts. The first part of the work is to penetrate the Earth's mantle, and the second part is to create angular movement from the build-up of torque on the Earth's sphere. The energy of a body is its ability to do work. Both work and energy are scalar quantities.

W_{lin} = the work to provide the force that performs the Earth's penetration
W_{lin} = 883×10^{24} kg km^2/s^2 = F (force) x s (distance that approximates a constant force acting on boring through the Earth) = Energy of a body in terms of the work it can do = $F_1 \times s_1 + F_2 \times s_2 + F_3 \times s_3 + \ldots\ldots + F_n \times s_n$, where $F_n = m_{impactor} \times a_n$ where a_n = de-acceleration of the Impactor = $(v_i^2 - v_n^2) / 2s$ and $t_n = 2s / (v_i - v_n)$

The first de-acceleration is from 45 to 10 km/s over a distance of 1200 km.; the second deacceleration is from 10 to 2 km/s over a distance of 3000 km.; the third de-acceleration is from 2 to 1 km/s over a distance of 500 km.; and the fourth de-acceleration is from 1 to 0 km/s over a distance of 500 km. The selection of these values is strictly intuitive for an icy object going through a molten mantle. Computer modeling can improve this de-acceleration process and may eventually become available.

$a_1 = [(45 \text{ km/s})^2 - (10 \text{ km/s})^2)] / (2 \times 1200 \text{ km}) = 0.802 \text{ km/s}^2$

$t_1 = 2 \times 1200 \text{ km} / (45 \text{ km/s} - 10 \text{ km/s}) = 69$ seconds

$F_1 = 0.25 \times 10^{24} \text{ kg} \times 0.802 \text{ km/s}^2 = 0.201 \times 10^{24} \text{ kg km/s}^2$

$WL_1 = F_1 \times s_1 = (0.201 \times 10^{24} \text{ kg km/s}^2) \times 1200 \text{ km} = 241 \times 10^{24} \text{ kg km}^2/\text{s}^2$

$a_2 = [(10 \text{ km/s})^2 - (2 \text{ km/s})^2)] / (2 \times 3000 \text{ km}) = 0.016 \text{ km/s}^2$

$t_2 = 2 \times 3000 \text{ km} / (10 \text{ km/s} - 2 \text{ km/s}) = 750$ seconds

F_2 = 0.25 x 10^{24} kg x 0.016 km/s^2 = 0.004 x 10^{24} kg km/s^2

WL_2 = F_2 x s_2 = (0.004 x 10^{24} kg km/s^2) x 3000 km = 12 x 10^{24} kg km^2/s^2

a_3 = [(2 km/s)^2 – (1 km/s)^2)] / (2 x 500 km) = 0.003 km/s^2

t_3 = 2 x 500 km / (2 km/s – 1 km/s) = 333 seconds

F_3 = 0.25 x 10^{24} kg x 0.003 km/s^2 = 0.0007 x 10^{24} kg km/s^2

WL_3 = F_3 x s_3 = (0.003 x 10^{24} kg km/s^2) x 500 km = 1.5 x 10^{24} kg km^2/s^2

a_4 = [(1 km/s)^2 – (0 km/s)^2)] / (2 x 500 km) = 0.001 km/s^2

t_4 = 2 x 500 km / (1 km/s – 0 km/s) = 333 seconds

F_4 = 0.25 x 10^{24} kg x 0.001 km/s^2 = 0.0003 x 10^{24} kg km/s^2

WL_4 = F_4 x s_4 = (0.0007 x 10^{24} kg km/s^2) x 500 km = 0.4 x 10^{24} kg km^2/s^2

a_{total} ≈ 0.195 km/s^2 de-acceleration over a distance of s_{total} ≈ 5200 km total distance.

t_{total} ≈ $t_1 + t_2 + t_3 + t_4$ = (69 + 750 + 333 + 333) seconds ≈ 1485 seconds = 24.8 minutes.

F_{total} ≈ $F_1 + F_2 + F_3 + F_4$ = (.201 + 0.004 + 0.0007 + 0.0003) x 10^{24} kg km/s^2 ≈ 0.207 x 10^{24} kg km/s^2 .

WL(total) ≈ (241 + 12 + 1.5 + 0.4) x 1024 kg km^2/s^2 ≈ 255 x 10^{24} kg km^2/s^2 .

The amount of available linear work is 883.1 kg $km^2/s^{2,}$ which exceeds the computed amount for de-acceleration of 255 x 10^{24} kg km^2/s^2. More energy is available for dispersion of impact debris, heat, light, noise, and compression of both the Impactor's and Earth's mantle.

L = torque to rotate Earth about the tilt axis orientation = F_{total} x r_{offset}
L = (0.207 x 10^{24} kg km/s^2) x (assumed 3000 km) = 6.21 x 10^{26} kg km^2/s^2 .

WR is the work to rotate the Earth from its initial spin axis orientation that is perpendicular to the ecliptic to a certain angle equal to the Earth's tilt with respect to the ecliptic plane. This work starts after the angular impulse is completed.

WR = L x Θ kg km^2/s^2, where Θ = angular displacement in radians

WR = 347 x 10^{24} kg km^2/s^2,

Θ = WR / L = (347 x 10^{24} kg km^2/s^2) / (6.21 x 10^{26} kg km^2/s^2) = 0.559 radians.
Earth's resulting tilt = (360 / 2 x π) x 0.559 radians = 32^o

To achieve the expected tilt of 0.401 radians x 57.3^o /radian = 23^o, the torque is increased by choosing a new offset for the center of impact = 4180 km below the Earth's equator. The work to rotate the Earth remains the same. Then the new torque is

L = (0.207 x 10^{24} kg km/s^2) x (4180 km) = 8.65 x 10^{26} kg km^2/s^2 and

Θ = WR / L = (347 x 10^{24} kg km^2/s^2) / (8.65 x 10^{26} kg km^2/s^2) = 0.401 radians

Of added interest is the angular impulse time span for the Earth's tilt after the Impactor almost comes to rest inside the depths of Earth's mantle.

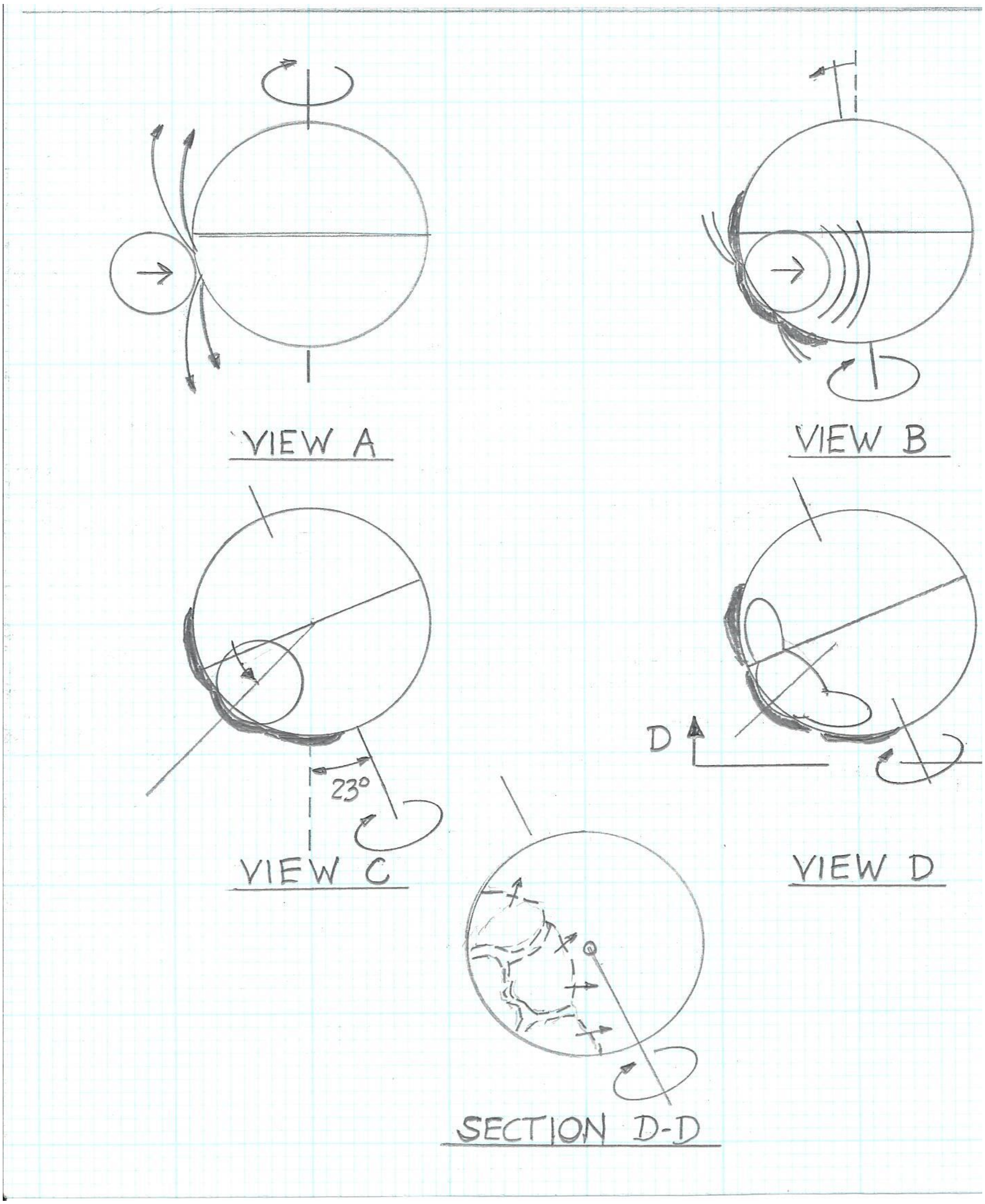
L x t = unbalanced angular impulse = $I(\omega_t - \omega_o)$ = change in angular momentum and hence, t = I (ω_t) / L (where $\omega_o = 0$) = (9.82 x 10^{31} kg km^2) x (0.00266 radian/s) / (8.65 x 10^{26} kg km^2/s^2) = 300 seconds = 5 minutes

The total time computed for this collision scenario is the time for the Impactor to penetrate the Earth, t = 25 minutes; the time for the angular impulse, t = 5 minutes; and the time to make the angular displacement, t = 2.5 minutes determined from the previous section. The sum of times is 32.5 minutes. No observers would ever survive to see this one-time event of the stars moving at supersonic speeds across the sky as Earth made probably the only major angular displacement in its history. The solar system does reveal other large planetary bodies brutally struck and heeled over. This event is common, but hopefully not too frequent.

This angular displacement occurred very quickly and helped to spread the materials that were ejected or spilled from the crater over a large area and on top of the Earth's already hardened surface. Any forming huge crater rim was destroyed. The small iron core of the Impactor eventually sinks toward the Earth's center to join the much larger liquid/solid iron and nickel core.

A depiction of how the Earth stabilized its new tilt axis is shown. In view A of the following diagram, the Impactor is making initial contact with the Earth's original atmosphere and crust creating a dispersal of debris from the Impactor's surface materials, the Earth's hardened crust, and from the Earth's original lithosphere.

17. How Earth Stabilized Its Tilted Axis



View B depicts the impulse force beginning to tilt the Earth's spin axis, cause an initial crater, and displace the Earth's mantle materials. This mantle displacement will create Earth's original rifts or cracks throughout its hardened surface.

View C indicates how the remaining rotational energy continues to tilt the Earth after the translational and rotational kinetic energies transfer. The original spin axis assumed to be close to the ecliptic plane changes by 23^0 after de-accelerating to zero angular velocity. This process is similar to pushing a spinning toy top just enough to tilt it but not enough to knock it over.

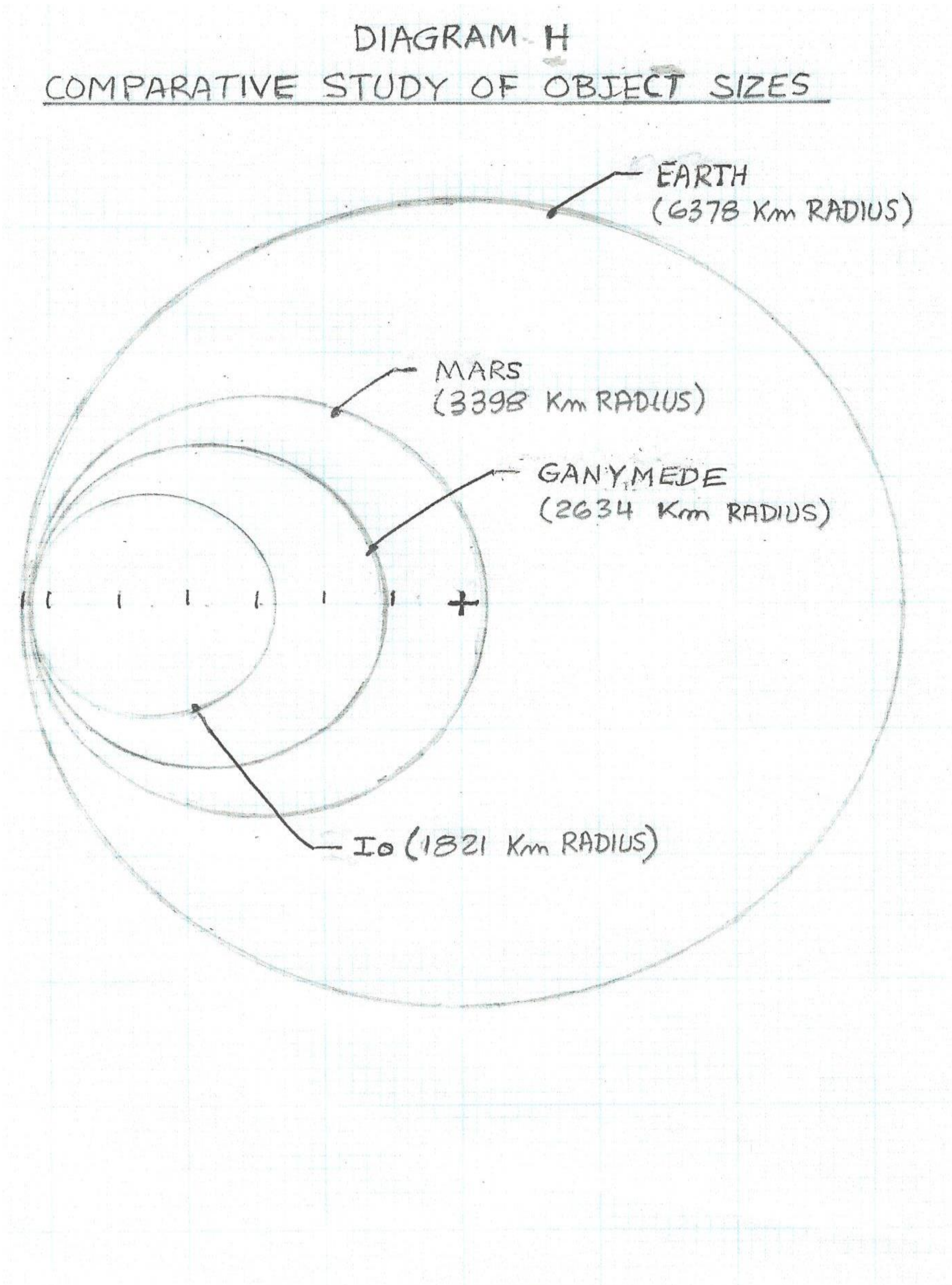
Much of the material of the frozen volatiles of the Impactor is melted and either mixed with the Earth's mantle or ejected outward from the crater into Earth's hot atmosphere, or mixed and flowed over the Earth's original crust to form the first continent.

In View D and Section D-D, the lighter embedded materials of the Impactor create an imbalance since the center of gravity no longer goes through the spin axis. The imbalance is significant since the average estimated densities of the Impactor and the Earth's mantle are 2.5 g/cm^3 and 5.5 g/cm^{3,} respectively. The trapped, forced, now gaseous volatiles spread outward circumferentially under the original Earth's crust and the newly formed supercontinental crust. Various forces are at work to perform that spreading and outward pushing. The hydrostatic pressures due to gravity push the volatile materials upward. The combination of centripetal forces, the forces from torque-induced precession, and the Coriolis forces spread the volatile materials radially from the central point of impact. All these forces are working together to adjust the center of gravity, so it again goes through the center of the Earth's spin axis.

Section D-D indicates how the radial spreading of the Impactor's materials initiates the break-up and spreading across the Earth's surface of the first super-continent. After the partial solidification of the supercontinent, the trapped volatiles underneath acts as lubricated rollers to move the newly formed continental crust radially outward from the central point of impact.

The Earth's core, which is much more massive than the Impactor, maintains the new spin axis until the different densities become more distributed and homogeneous through forces previously described. The change in Earth's orbital position brings it closer to the Sun and very close to its new neighboring planet, the Moon. The combination of these added changes of gravity forces helps to stabilize the tilted spin axis.

18. Comparative Study of Celestial Object Sizes



19. Conclusions from Calculations for the EMM Hypothesis

These calculations are certainly an approximation and do not possibly account for all the details. I certainly welcome any computerized analysis, if possible. This case study does indicate a certain probability for such an Impactor and the portrayed post-collision events.

From the conservation of momentum, a certain linear momentum vector, R, determines the Earth's motion immediately after the collision. An almost inelastic collision is utilized where most of the Impactor embeds inside the Earth. The equation assumes vectors are closely in one plane, that of the ecliptic. An impact angle of 90 degrees to the Earth's orbit produces a reasonable resultant velocity of 17.2 km/s and a vector angle of 22 degrees inward toward the Sun. The final linear momentum vector of Earth after the collision could be further enhanced if it includes the gravity field of the much larger postulated planet that carried one of its satellites, the Impactor, into the Earth's orbital region. If indeed, the rogue planet was a satellite of another planet with a very large elliptical or a non-returning hyperbolic orbit, this hypothesis does not require the presence of another separate planetary system.

Utilizing the conservation of energy, various increasing velocities of the falling Earth determine different points along its trajectory in going from a 2.7 AU orbit to a 1.0 AU orbit, the existing one for the Moon. The initial energy components, $K_i + Ug_i$, are set equal to the final components, $K_f + Ug_f$. $Ug_f – Ug_i$ represents the potential energy lost by the masses falling toward the Sun. Determining K_i assumes the initial velocity is vR immediately after impact. K_f is computed initially to have an orbital speed higher than what Earth currently has. The computed final falling velocity of 35.4 km/s is reasonable in that it occurs between Earth's present orbital velocity of 30 km/s and Earth's escape velocity of 42.1 km/s. The initial velocity of 35 km/s is assumed to conservatively account for the effect of other gravitational fields such as the Impactor's parent planet, possibly Mars, and the Moon's that may have initially decreased the velocity of Earth.

To account for a reduction in orbital velocity, the Earth exchanged energy with the Moon to achieve a synchronous orbit. Impulse momentum energy is added to the Moon each time as the Earth passes, thereby slowing the Earth's velocity incrementally. The impulse momentum pulled the Moon into alternating higher or lower orbits for each passing. This process, as computed, requires greater than 23,000 orbits or close-encounter type passings until the Earth's velocity became synchronized with the Moon's orbital velocity of 30 km/s. Very close to the time of synchronization, the Moon falls toward the Earth, gaining an orbital velocity around the Earth of about 1 km/s. In performing this step with kinetic and potential energy conserved, the Moon spiraled outward from 90,000 km to 240,000 km, attaining a stable orbit. As computed, approximately 22 spiraling orbits achieved this separation distance of 240,000 km using the conservation of kinetic and potential energies.

All these events occurred before 3.8 bya. Now the Earth and Moon have steady tidal forces or accelerations that eventually slow the rotational period of the Earth from 19.6 to 24 hours.

The Moon, in turn, stops spinning and becomes tidally locked to the Earth very quickly compared to the total age of the solar system. The new tidal forces help stabilize the Earth's spin axis, which is now tilted, aids in volcanism that release volatiles of the Impactor that are trapped under Earth's primordial crust and induces plate tectonics and the resulting continental breakup and drift. Continuing tidal forces become lesser but still cause the Moon to recede about 38 mm each year as the Earth imperceptibly increases its rotational period.

Many mysteries of the Earth-Moon system are now resolved. No bizarre collision mode and rotational period are required to accrete debris for the Moon and provide the desired angular momentum. The Moon was already a planet in the pristine solar system and possessed its angular momentum before the Earth became its companion. A solution now addresses why the Moon is the only satellite in the solar system that acts like a planet and is held in its orbit by the Sun's gravity and not the parent planet's gravity. Most questions that arose during the Apollo Missions are answered by this hypothesis, such as the dating of Moon rocks and the much later cooling of the surface mares.

All the calculated values seem reasonable and plausible. The losses due to the impact are estimated at 10 % of the total initial linear momentum of the two bodies, which is plausible when comparing the amount of debris left behind from the impact. The collisional debris was negligible compared to the other masses involved and is neglected in the equations. But this debris does explain the reason for the Main Belt of asteroids, Jupiter's Trojan asteroids, random non-coplanar bodies, the later impacts on the inner planets, the captured satellites with collisional properties, and very importantly the Later Heavy Bombardment (LHB) period.

The impact location in all probability was at a latitude well below the equator line, thereby causing the tilt of the Earth. A basic trend for solar system formation indicates that all the major bodies have similar rotational vectors that are mostly perpendicular to the ecliptic plane. Major impacts, including Earth's impact, certainly can explain why some planetary bodies deviate from this trend.

Other factors enter the picture to aid the Earth in finding the Moon's orbit. The falling Earth crosses the orbit of Mars. The fuzziness of the overlapping gravity fields of the Moon and Mars gives gravitational flow to the inward-moving Earth to help slow and guide its approach to the Moon's orbit. I refer to Course No. 1333, Chaos, Lecture 19, The Chaos of Space Travel, in the Teaching Company's Lecture Series. Many college courses were taken at home using video CDs by the Teaching Company, which was founded by a U.S. astronaut. I have sought much information from these college lecture series.

The Titius-Bode law is another factor that coaxed the Earth to settle into its current orbit. The Titius-Bode law represents a mathematical prediction for the planetary orbital distances from the Sun. Of course, this mathematical phenomenon predicts the average orbital distance of the asteroids where Earth resided before its collision with the proposed Impactor. This law represents the so-called gravity waves created by a massive object, our Sun, moving through a medium of neutrinos, electrons, and photons that are considered massless constituents in the so-called vacuum of space. This medium has not yet been detected by science in its waveform structure. Man's instruments are not sensitive enough, but a massive object such as a planet can detect and respond to these gravity waves. The waves become shallower and exponentially farther apart from their source similar to a stone dropped into the water and causing circular ripples that radiate outward. The difference in this similarity is we only see the waves on the surface of the water, which rapidly dissipate. These ripples or waves are maintained in space as long as the object, especially a massive star, maintains its velocity. These waves are different in their frequency and amplitude for different masses and velocities and interstellar mediums (ISMs) such as is the case with the main satellite orbital distances around Jupiter and Saturn and distances of exo-solar planets orbiting other stars. And predictably, not all these gravity troughs are filled with orbiting bodies, especially the more shallow troughs farthest from the source body.

Once an orbiting planet or satellite moves into the trough of one these waves and its velocity is between orbital velocity and escape velocity, it stays in this orbit similar to a speeding race car being held on a curve when turning because of a banked racetrack. If the orbiting or turning speed is too high, and the vector difference is too high for the tangent line of the curve, the body will escape the groove or wave trough and seek another wave trough. The general theory of relativity predicts the bending of photons around a massive object but does not yet test the concept of waves of photons and other so-called massless particles of leptons. These massless particles move outward radially due to a fluid-like wake in the medium caused by a moving, massive object. These leptons are also emitted from stars and added to their wakes in the medium. Also, these leptons emitted by the Sun or any star are either charged electrons or chargeless neutrinos that are the major suspects for creating gravity waves. These waves aid in capturing and locating lessor objects around much more massive objects. Celestial mechanics need to recognize such possibilities.

When the Earth was knocked inward from its pristine orbit around the Sun, only certain options could occur:

1. Find a co-orbital residence with one of the inner planets: Mars, Moon, Venus, or Mercury.
2. Collide with one of the inner planets or fall into the Sun.
3. Be slung around the Sun into the outer solar system with a highly elliptical orbit and be dangerously perturbed each time during its annual orbit that crosses other planetary orbits.

It was very fortuitous for humanity that the goddess Earth chose the Moon's orbit. The distance from the Sun would place it in the warmer part of the liquid water belt, and the Moon's tidal forces would be just enough to promote primitive life after the Moon sufficiently receded. The initial close distance caused huge pulls on Earth's crust that created too much heat and crustal activity for more organized life forms. But these severe tidal accelerations end well before 3.8 bya to provide ample time for living organisms to start and begin evolving in a more settled and friendly environment. Since the Earth has a serious tilt in its rotation to its orbital plane from the impact, the Moon's gravity field provides stability to the Earth's spin so that only a constant, repeatable 26,000-year precession or wobble would occur along with some other trivial wobbles. The first, single continent located in high southern latitudes and around the South Pole created the combination of the Earth's mantle and Impactor materials oozing through the immense crater hole in the crust. The lighter mantle materials then displaced or moved outward and over the top of the existing oceanic crusts. The heavier oceanic crusts then sank farther into the mantle to create subduction zones. The tidal forces continued acting on the Earth's crust and aided the tectonic plate movements and caused the separation and spreading of the original continent and abetted further differentiation of trapped volatiles via hydrostatic forces and volcanism.

This hypothesis for the Earth-Moon system provides a marvelous concept but has a serious incongruence. What was the source of the Impactor and possibly its parent planet or star? The completion of the pristine solar system was assumed. The planets were mostly differentiated, and the Sun's youthful solar winds mostly evacuated interplanetary space. How did such a large body, the size of Mars, survive all those years between 4.6 billion years ago (bya), the beginning of the solar system, and the Late Heavy Bombardment period of 3.9 bya without being destroyed, ejected, or taught to behave by orbiting in some stable, coplanar, almost circular orbit? The present modeling and observations for proto-star disks point to an accretion formation process or some other formation process for the planets that occurs within 100 thousand years or less for a one-solar mass, which is not near enough time to accrete the outer planets. This rapid accretion formation process certainly cannot explain the existence of more planets forming 600 to 700 million years after the star and its original planets formed.

20. Solar System Disruptions

If you stand back and look at the solar system as a whole, you know that other major disruptions have occurred since its original formation. Evidence of these disruptions are planets with spin tilts, retrograde spins, Uranus' spin axis almost

90 degrees to the ecliptic plane, meteor bombardments of different times, satellites having collisional properties, satellites having non-coplanar and retrograde orbits, and the gas giants having large spots more than likely caused by collisions into their frozen surfaces.

The only answer for these solar system anomalies -- features that deviate from the general trends of coplanar, almost circular, same directional orbits and spins - are disruptions by major collisions or near misses of bodies that do not obey the overall trends. Where is the source of these massive bodies? How did they form? Why did bodies not accrete with others much earlier during the period between the formation of the solar system, 4.6 billion years ago, and the Late Heavy Bombardment period of 3.9 billion years ago? This period is a span of 700 million years. If accretion was the major mode of planetary formation, why did the asteroids themselves not accrete over the past 4.6 billion years? Why have not the materials in the rings of the outer planets accreted or fallen into the planet? Why do the comets orbiting the Sun still have volatiles or charged particles that produce comas for these past 4.6 billion years? These lighter volatiles should have boiled away and destroyed the comets millions of years ago after a few thousand orbits close to the Sun.

The answer is simply that these "later bodies" of the solar system may not have formed during the early period of the solar system. These "later bodies" as large as Mars and Pluto and as small as grains of dust around Saturn was possibly captured at much later periods by the various gravity fields of the Sun and its already existing outer planets. As proposed, this process of capturing interstellar materials and orbs continues to this day. The evidence is the rings around the outer planets, the comets of both regular and irregular orbits, and the recently discovered Plutonian minor planets or Kuiper Belt Objects (KBOs). The Kuiper Belt and the nonproven Oort Cloud cannot begin to address all the unusual early events in our solar system. The new claim is that our illustrious spaceship, the solar system, moving around the galaxy at 250 km/second every 230 million years is constantly running into and capturing interstellar materials that may either enter the inner solar system or perturb existing Kuiper Belt Objects that then begin to orbit closer to the Sun.

These questions became the seeds for one of my next hypotheses, “The Collocation of Stars and Planets” (CSP), that deal with the original Kuiper Belt Objects (KBOs). These objects were initially gathered by the proto-star disk gravity field and eventually ejected to the outer perimeters by larger planetary-size objects. Their resulting elongated, elliptical orbits can occasionally perturb other outer-perimeter bodies, if not intruders from interstellar space. Then these original objects of the proto-star disk can also become the so-called “later bodies” that visit the inner solar system between large intervals of time and cause havoc. More generally, the KBOs follow more prograde orbits, whereas interstellar intruders may just as well follow retrograde orbits causing more damage in a collision due to the higher kinetic energy of their combined orbital velocities.

21. The Earth’s Metamorphic Transition

Hopefully, this dissertation resolves the Moon’s enigma. For future discussions, “Earth’s Metamorphosis (EMM) Hypothesis” provides a name for the creation of the Earth-Moon system. The Earth truly went through a metamorphic process after this major impact.

1. The Earth moved to a warmer orbit and a safer orbit more out of reach of dangerous rogue planets.
2. The Earth’s spin axis tilted, causing seasons and atmospheric and ocean motions.
3. The Earth gained a Moon that provided life-giving tides.
4. The Earth gained from its foremost Impactor more needed volatiles such as CO_2, H_20, NH_3, and CH_4 that enhanced the oceans and atmosphere and produced abiogenic petroleum, an abandoned hypothesis that needs re-visiting.
5. The Earth gained high ground above sea level, the continents, providing more opportunities for life forms.
6. The Earth gained entrained volatiles in the upper mantle that created plate tectonics and volcanism to re-supply more volatiles to the atmosphere.
7. The Earth provided a sustainable platform either in an environment of liquid or gaseous states for life, based on liquid water and carbon molecules, unlike the other planets and satellites of the solar system.