# The Ring About The Earth at 2300 BC

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Summary *As postulated in earlier papers, dust in the Earth's North Polar region at 2300 BC initiated widespread geophysical changes. The dust was a result of the Earth encountering a massive meteoroid stream, the Taurids. The event was sufficiently traumatic that religions were formed in essentially all cultures on the Earth. Thunderbolts were a prominent theme of the religions, but a new theme appeared - a ring surrounding the Earth. A possible mechanism for the ring formation was capture of small particles in the Earth's upper atmosphere coupled with later particle fragmentation.*

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This paper is a continuation of the saga of the event at 2300 BC. Based on my last three papers [1], the event at 2300 BC has been postulated as being caused by dust over the north Polar region triggering the Arctic region into an ice-covered configuration. This much colder environment in the Arctic did two things:

(i) it affected climate all over the Earth and was the principal factor in cultural disruptions and migrations and

(ii) the colder environment caused glacial growth.

The differential crustal loading from the glacial growth and loss of oceanic water to the glaciers caused crustal movements and earthquakes. The crustal movements and earthquakes in turn caused widespread geomagnetic transients.

What was it that caused the dust over the north Polar region that started all the geophysical effects? There are two possibilities: the more mundane one would be a volcanic eruption; the more dramatic one would be an encounter between the Earth and a massive meteoroid stream, the Taurids. I strongly favour the latter, based on the appearance of new religions in

cultures all over the Earth at that time, reflecting an extraordinary happening; this would not have occurred in the case of a volcanic eruption. The religions have, of course, disappeared but their residual mythology remains.

There is general agreement that the significant mythological literature in the Middle East originated in the last centuries of the third millennium BC. Kirk [2] addresses the mythology of the Sumerians in Mesopotamia (Iraq) and that of the Akkadians who conquered them at 2340 BC:

> 'Most of the surviving myths in Sumerian were written down, on the tablets we possess, as early as about 1700 BC, but can be shown on linguistic and other grounds to have originated by about 2300 BC. Many of the surviving Akkadian myths, on the other hand, are known primarily from Neo-Assyrian tablets recovered from the library of Ashurbanipal in seventh-century BC Nineveh, but can be shown to go back to the Old Babylonian era before the middle of the second millennium BC. Some contain still earlier material.'

Lenormant [3], about 100 years ago, spoke about a 'religious evolution' occurring in Sargon I's time, at the beginning of the Akkadian empire (about 2300 BC). Oldenburg [4] dated the mythology of the Ugaritic people in northern Syria to the same time:

> 'Although most (Ugaritic) mythological tablets, according to the colophons of several tablets, were inscribed ... in the first half of the fourteenth century BC, the myths recorded on them may go much further back, some even to the turn of the third to the second millennium BC.'

Egypt provides clear dating of relevant mythological material to the 2300 BC time period. According to Anthes, a principal scholar in the field [5]:

> 'The basic concepts of Egyptian mythology were already established about 2200 BC, and the succeeding changes represented an increase in variations and combinations rather than alterations of the concepts.'

He established this date by a reference to the appearance of this mythology in the Pyramid Texts between 2300BC and 2200BC [6] at the end of the 5th Dynasty of the Old Kingdom. It is generally agreed that the Pyramid Texts (written on the walls of pyramid tombs of Egyptian rulers) are the earliest source for Egyptian mythology. These texts are also referred to as the *Book of the Dead.* This is supported by Budge [7], a specialist in Egyptian literature:

> 'The chief features of the Egyptian religion remained unchanged from the Fifth and Sixth Dynasties down to the period when the Egyptians embraced Christianity'.

Although the dating of the Rgveda in India is controversial, a number of authors place the origin around 2300BC [8]. One potentially important dating technique is based on astronomical observations, in that the *naksatra* calendar is referred to several times in the Rgveda. Authorities generally agree that on the the astronomical evidence, the 24th century BC is the most likely compilation date of the *naksatra* calendar [9]. Major Iranian deities have been identified with Indian counterparts in the Rgveda, allowing dating referencing to the Indo-Iranian separation at about 2300BC. In Greek mythology, Zeus and other deities can

be traced to the Indo-Europeans who moved into that region around 2300BC. Strong linguistic links between the Balkan cultures and the early Indo-Europeans around 2300BC could possibly serve as a dating reference for that region. The Hebrew deity Yahweh can be traced to his earlier identity Yah, worshipped by several groups of people in the 2300BC time period

Britain's earliest mythology comprises successive invasions of Partholan's people, the Formorians, Nemedians, Firbolgs and the Tuatha de Danaan, dated from 2700-1900 BC (centred at 2300 BC). A number of investigators have voiced opinions that the sequence of invasions is an artificial chronological arrangement of originally separate traditions referring to the same event, based on similarities of names, activities and leaders. Interestingly, the same situation exists with the anthropomorphised historical Five Sovereigns of Chinese mythology - Hwang-ti, Shen-nung, Yao, Yu and Shun, dated between 2700 and 2200 BC. There is a sizeable amount of evidence for the mutual equivalence of the Five Sovereigns, as well as their potential as manifestations of the postulated event at around 2300 BC. The almost random variation in the reported order of succession reinforces this idea. A reliable dating reference, appearing in the traditions of India, Egypt, and China, is the event described as occurring when the Pleiades was the constellation of the vernal equinox, which occurred at about 2300BC.

## Thunderbolts and the Ring Around the Earth

As would be expected, the religions at 2300BC had much to say about thunderbolts hurled at the Earth, reflecting the fall of meteoroids. Surprisingly, the religions also appeared to speak of a ring extending around the Earth. This interpretation of the mythology is a possible viable alternative to other current interpretations.

Since the ring was observable everywhere on the Earth's surface, it would be expected that it would be described by all cultures - and it was. Most commonly, it was described as a circle of flowing water. I have also found 24 interpretations, including a celestial mountain, a serpent holding its tail in its mouth, a time regulator, a chariot wheel and a set of horns. This paper primarily addresses the flowing water.

The water interpretation could have been due to two possible factors. The first is related to unevenness in the structure and density of the ring: since the material would be moving at different velocities in different orbits around the Earth, it could have looked like unevenly flowing water. The second is that the reflection of sunlight off the ice particles in the ring may have appeared like sunlight reflecting off water on Earth. Probably both factors were involved.

The records clearly denote a sea, ocean, river or stream that was conceived as cosmic, heavenly, or celestial. The water is described as encircling, surrounding, girdling and extending beneath the Earth - a common adjective is 'endless'. The appearance of the celestial waters, in most cultures, goes back to very ancient times and is associated with the process of creation. Gaster and Brinton have recognised and discuss the 'primality' of water, in that in essentially all cultures there is a tradition of water existing before anything else [10]. Clark also recognises the commonality of myths, that before the beginnings of all things was the Primordial Abyss of Waters, stretching endlessly in all directions [11]. Another common tradition is that life is said to evolve from celestial whirlpools [12]. The celestial river in many cases is a counterpart or a continuation of an actual river on the Earth. The terrestrial

river, as would be expected, is considered sacred. In some cases, there is a general veneration of waters.

The circularity of the ring extending from horizon to horizon is reflected in the water being described as issuing forth from or disappearing into an abyss, otherwise alluded to as a cistern, tank, reservoir or pool, spout, well, tunnel, or cave in the ground. In some cases, there are references to the water issuing from two holes in the ground, two deeps, or two horizons, or flowing from a lake and returning to it at a later time. The appearance of the ring in the sky is also described as a disc or an arch. A possibly misleading depiction is waters rising to the sky, inferring a flood. The restricted flow of the waters in the sky is reflected in the terms 'pipe or tube, band, binding, rope, loop or cord.'

Reflected sunlight from the dust and ice particles is graphically articulated. Descriptive terms are 'resplendent, gleaming, bright, brilliance, splendour, radiance, beauty, awesome, fire in the waters, glass or crystalline'. The ring is also described as a mirror, implying reflection of sunlight. Von Dechend and de Santillana make the observation that in ancient times, 'fire was thought of as a great circle reaching from one celestial pole to the other' [13].

I have researched the religions (and consequent residual mythologies) in 17 cultural regions - Middle East, Egypt, India, Iran, Britain, China and Central Asia, Greece, the Hebrews, Scandinavia, Europe, the Pacific Ocean, North America, Mexico, Central America, Peru and South America, Japan and Africa. In this paper the Middle East and Egypt are emphasised, since they had developed writing systems by 2300 BC. Not only could the event be documented by people who were direct eye-witnesses but the writings themselves can be dated.

Early writers in the Middle East refer to the all-embracing great cosmic sea [14], with stories of creation including the celestial waters. In an old Babylonian creation myth, at first 'all lands were sea, and in the midst of that sea was a spring which served as a pipe' [15]. The Babylonian creative principle of the universe was water or a water-god who is often called tarkullu 'rope' or markasu 'band of the universe' [16]. The Tigris and Euphrates rivers running through Mesopotamia were thought of as streams of heaven [17].

There were various concepts to reconcile the heavenly rivers with the rivers on the Earth. The general belief was that the water in the sky formed a continuation of the Nile or Euphrates, or was the source of those rivers [18]. The Greek Pausanias relates the strange belief of the ancients that the Euphrates, after disappearing in a marsh and flowing a long distance underground, rises again beyond Ethiopia and flows through Egypt as the Nile [19], or that both the Nile and Euphrates flowed underground and then above ground [20]. The Akkadians called the Euphrates 'the rope of the world', 'the heavenly river that surrounds the earth'. A final note is that Josephus, the Jewish historian, relates a tradition that 'the Ganges, Tigris, Euphrates and Nile are all but parts of one river which ran round the whole earth' [21].

There was prevalent deification of rivers in Babylonia; gifts of high value were thrown into water and therapeutic virtues were attributed to running waters. A good example was the healing waters of the Jordan [22]. Rivers were thought to be fed from a subterranean ocean or by a great deep of fresh water, quite distinct from the ocean [23]. In addition to the heavenly river being a counterpart to an earthly river, it is also designated by various names such as the *Apsu*, *Engur* and *Hubur*, which have no terrestrial counterparts.

The Sumerians conceived the Apsu as a single body of water completely surrounding Earth [24], with its pure light reaching heaven [25]. The word *ps'* denotes 'the ceasing, the not being of the earth (i.e. where the earth stops)'; the word is connected to the Hebrew *apse eres* 'ends of the earth' [26]. Other root words are *ab* 'hole, hollow, sea' [27] and *samu* 'sky', 'heaven' [28]. The Greek *abyssos*, adopted from the Akkadian *apsu*, means an extremely deep hole in the ground [29]. Burrows remarks that all texts permit the view that the *apsu* is a cistern, tank, reservoir, or pool [30].

According to other ancient traditions, there is a mighty river, whence all streams spring, the 'river, creatress of everything' corresponding to the Sumerian goddess Engur 'the mother who bore heaven and earth.' This river is also called Hubur 'river of fertility' and is also interchangeable with the Apsu [31]. The term denotes the sea as a single body of water completely surrounding the universe, above, below and on all sides [32]. Hubur is associated with the word 'deep', 'depth' so as to be interpreted as being in the underworld; it is called the 'river of the underworld' [33].

The Egyptians definitely thought of the heavens as liquid. The word applied to the sky is sometimes delineated as a well of water and sometimes also by a stream of water. Interestingly, meteorites are also said to be made of the same word [34], thereby linking the ring phenomenon with the meteoroid fall. Understandably, the principal river in the sky for the Egyptians was the Nile. I have already related cosmological concepts of the Nile together with the Tigris and Euphrates rivers. Still another concept was that the Nile appears through two subterranean passages leading from the underworld [35]. These two sources of the Nile are called 'leaper' and 'spouter'. The names have come down to us in the Old Testament in that two of the four rivers in the Garden of Eden, Pison and Gehon, are literal translations of the Egyptian names [36]. In some of the traditions, the river is described as emanating from the abyss of earth, in others as falling from the skies [37].

If there were a number of concepts on the configuration of the Nile and Euphrates, the people had no problem visualising Nun (or Nuu), the primordial ocean, which preceded all things [38]. The texts speak of the earth surrounded by water, the Great Circuit or Great Circular Ocean, 'the Great Green'. This is the product of the first of the gods, Nun, from whom the Nile and rain had their origin. The ends of the ocean disappearing in darkness and endless space lead back to the subterranean waters [39]. 'Nun came forth from ... (and covered) this land to its limits. It stretched to the two borders (of the land) as in the first time ...' The hieroglyphics in the inscription denote the flowing forth of water from a cavern or well [40]. The composite hieroglyph for Nun denotes (i) a bowl for containing liquids, (ii) the sky and (iii) water. Sometimes, the sky symbol is inverted, implying that the water extends below the earth and surrounds it on all sides [41]. Nun is addressed throughout the Pyramid Texts, dated to the end of the 5th Dynasty [42].

Flowing water in the sky also shows up in other cultures. The best-known celestial river was the Greek Oceanus -'Oceanus surrounds the circle of the world ... girdling the whole earth coronet-wise with encircling band' [43]. In the Indian Rgveda, Soma 'runs through heaven across the spaces with his stream' [44] and has a *ghora* 'awesome form' [45]. Iranian literature states that the Xvarenah is a glowing or fiery nimbus [46], which dwells in the sea Vourakasa as it circles the Earth [47]. ) In the Hebrew traditions, "The Ocean surrounds the world as a vault surrounds a large pillar. And the world is placed in its circular form on the fins of Leviathan". [48]. In Japanese mythology, heaven is crossed by the heavenly river, Ama-no-kawa, typified by a stream having pebbles in its bed, similar to streams in Japan [49]. It is

called 'the Rocky Bed of the Tranquil River of Heaven' [50] and the 'True-Pool-Well of Heaven' [51].

The British *Arianrhod* 'of the Silver Wheel, silver-circled,' turns the wheel of heaven [52]. 'The goddess of the silver wheel on behalf of the Britons threw around the sanctuary of the rainbow a stream which scares away violence from the earth and causes the base of the former state around the circle of the world to subside' [53].

In Chinese traditions,

> 'The great earth lies in the middle of the world sea ... water flows around all the sides of the great earth as the juice meat surrounds the seed of a fruit; as the white surrounds the yoke of an egg' [54].

> 'Heaven is beyond earth, and water is beyond heaven. The water floats heaven and carries the earth. The celestial hemisphere and the disk of the earth both swim on the ocean encircling the earth and extending beyond the sky' [55].

For Scandinavia, there is a statement in Sturluson's Edda, 'The earth is circular in shape, and outside it is the deep sea' [56]. The Letts in the Latvian region recognised a celestial ocean which they called Daugawa 'Great Water [57]. The Aranda of Central Australia tell how the Earth slowly emerged from an endless sea, a sky river with an inexhaustible supply of sweet water [58]. In the Pacific, a principal deity is known as 'Tane of the whirlwind', 'Tane of the great water source', 'Tane turning completely' and 'Tane of the heavenly cloud' [59]. There is frequent reference in Maori mythology to the 'broad path of Tane' [60].

The Navaho Indians of North America have a mythical 'whirling lake' or whirlpool called To-nihilin 'waters that flow around' - the whirling lake had no outlet and no bottom and was connected with the Ursa Major constellation [61]. In the traditions of the Chorti Maya of Central America, 'Long ago, the sea, from time to time, rose up, in its waves, and rose up standing like the clouds. And when it rose up standing, then it let itself come down, and covered everything on the earth ... there was one sea which was very large, and just like milk, perfectly white; they say that they were stuck together, the sky and the sea' [62]. In the oldest Peruvian traditions, the terrestrial Vilcanota River is considered to be a mirror, reflecting the Mayu, the celestial river. As the Vilcanota River flows from the southeast to the northwest, it carries terrestrial water to the edge of the earth. The water then flows into the mar, the cosmic sea, which completely encircles the earth [63].

In summary, all 17 cultures have celestial waters in their ancient traditions, with 16 of them clearly asserting that the waters surround the Earth. Further support for the model comes from the ring orientation. From many accounts, the ring was aligned to the north with an inclination of about 70°; it was very close to both Ursa Major (Great Bear) and Ursa Minor (Little Bear) constellations. A powerful correlation item is that 10 of the 17 cultural areas linked the ring to the Ursa constellations; moreover, the ring is not linked by any cultural area to any other constellation. Furthermore, three other cultures oriented the ring to the north or northeast.

## Ishtar

In addition to flowing rivers, there are many deities that represent the phenomena. I am only going to review Ishtar in this paper because of her controversial nature - identified with the planet Venus, to the bow-stars Sirius and Spica and to the moon. Ishtar was known in Uruk in the 3<sup>rd</sup> millennium BC [64] and was an important Ebla deity [65]. There is also evidence that she was worshipped by the Akkadians in the time of Sargon I [66]. Consequently, she can be placed in the latter centuries of the third millennium BC. Ishtar is intimately associated with the water that is said to flow around the Earth. The Akkadian notion of the universe was 'the deep', a flowing stream which surrounded the earth and was sometimes compared to a snake, sometimes a rope.

It was personified by Innini and referred to as 'the river of Innini'. Ishtar is always regarded as the mother of this stream Ishtar, as the mother of Erech, was worshipped as A, meaning the waters, and as A she was the wife of Ia. The name means the house (I) of the waters (a), so that to call the mother-goddess A his wife, is merely a mythical way of saying that the mother of life was the life-giving water, the encircling ocean. It was as the ocean-mother that she was called by the Sumerians Sirri-gam or Shir-gam, the enclosing snake, and it is in this form that she is the goddess Nana (the lady), one of the names of Istar of Erech, who was the mother of the ocean called 'the snake or rope of the great god', the river of Inini the divine lady [67]. Her name means 'irrigating ditch', 'she who waters', 'the self-waterer' [68]; it is related to the root words 'tube', 'spout', 'to turn about', 'to bind', 'to unite' [69].

Numerous items exist on the appearance of Ishtar as a circle in the sky. There is a reference to Ishtar who 'fills the circle of heaven' [70]. Ishtar is identified with Mah [71], whose throne supports a distinctive thing - a broad band shaped like the Greek letter Omega. This symbol, called *dingir-Mah*, also occurs with Marduk. The symbol is called *markasu* rabu 'the great band'. The symbol is also used in the sense of the divine power or law that holds the universe together [72]. Other descriptors of Ishtar are 'horned', 'horn-producing', 'ribbed', 'bowed' [73].

Ishtar is well-known for her light and beauty in the heavens. She has the epithets *Nin-as-na* 'mistress of the heavens' and Nor-ile 'light of the gods' [74]. The Sumerians refer to her as the ' ... lofty goddess ... resplendent', 'light of heaven, which arises over the land like fire ... opens the lock of the bright heavens' [75]; 'To the pure flame that fills the heavens ... who shines like the sun' [76]; 'The one whose radiant rising is exalted in the heavens' [77]; 'Enclosed in fire (*gis-bar*) and charged with splendor (*melamnu*) [78]; ... your station (on the sky) higher than all' [79]. Her brilliance actually may have been somewhat overpowering; 'The lady who fills the firmament of heaven (am I); Through my appearance, fear is established in the heavens' [80]. The *melamnu* has the connotation of an 'awe-inspiring luminosity' [81].

I recognise that there is much evidence that Ishtar is identified with the planet Venus, the Moon and the stars Sirius and Spica. The planet Venus will be addressed first. I have devoted a chapter in my book to the position of the ring relative to the Sun and its resultant appearance to observers on the Earth. Specifically, the ring would not be illuminated at night but would first be illuminated at dawn, grow through the day and then recede at sunset. This is amply described in the literature: the Semitic goddess Ishtar is shown in the literature as representing both darkness and light. She is addressed as 'She who is Darkness, the Mother, the Emanar of the Dawn' [82]; 'Causing her splendour to shine as one that carries a torch through the night', 'Holding the morning light in her hand' [83]. 'Light of heaven, which arises over the land like fire ... opens the lock of the bright heavens' [84]. Significantly, she is addressed as 'the star (which) increases' [85]. She has a 'robe of splendour' which she loses on descent to the underworld [86], reflecting the period after sunset when the Sun descends in

the west. Later, as 'Morning Star' and 'Evening Star', it was reasonable that she was identified with the planet Venus that only appears in the sky in the morning and in the evening because of its orbit. However ... I don't feel that the above description fits the appearance of the planet Venus.

The bow is the characteristic sign of Ishtar [87]. The stars Sirius and Spica are said to have both received the name of bow-star after identification with Ishtar [88]. The operative term in that sentence is 'after'. The common sign of Ishtar has also been interpreted as a crescent, linked to the Moon, because of its appearance. Again, I feel that this was a later identification, again based on the initial Ishtar appearance

## The Physical Formation of the Ring

The final step is to discuss possibilities on how the ring could have been formed. The actual physical event leading to the formation of the ring is, of course, not known and may never be. My interest is only in reaching a minimum threshold to persuade the sceptical reader that such an event could have physically happened.

Two critical aspects of the ring must be considered in the discussion. Firstly, the ring was formed in only several days. According to the mythological accounts, the meteoroid stream encounter only lasted for days, with the ring existing immediately afterward. Secondly, it doesn't seem from the mythological accounts that the ring lasted very long, since there is no mention of a specific time that the ring dis-appeared. It is possible that the life of the ring was no more than weeks or months, gradually thinning out and disappearing. Its presence, however temporary, was sufficiently awesome that it fostered important new religions around the Earth, the mythologies being the remnants of those religions.

On the subject of ring formation, I could spend a lot more time on schemes that won't work than anything that will. Four planets in the Solar System - the outer planets, Saturn, Jupiter, Neptune and Uranus - have rings, although the rings differ in orientation, configuration and composition. There is general agreement that the formation of the rings was the same for all four planets; namely, collisions involving small bodies already circling around each of the planets. Furthermore, each of the four planets have sufficient mass (much greater than Earth) so that particles passing by even at high speeds can be captured into orbit.

Unfortunately, a collision processes for ring formation similar to the outer planets doesn't apply to Earth. Firstly, the Earth doesn't have small moons or satellites to collide with each other and generate small particles and dust; secondly, the process takes a lot longer than a few days to create a ring. Furthermore, the Earth has insufficient mass to capture high speed objects such as passing meteoroids.

One early thought was that meteoroids might be slowed down in travelling tangentially through the Earth's atmosphere so as to be captured in orbit. A computer simulation showed that because of the very high differential velocity of the meteoroids relative to the Earth there would be insufficient slowdown for capture. Furthermore, when meteoroids slow down by atmospheric drag, the meteoroids burn up before appreciable slowdown occurs [89].

Fragmentation of bodies passing close to Earth due to exceeding Roche's limit doesn't work either [90]. Although fragmentation does occur, low separation velocities result in the

fragments continuing to travel approximately at the same velocity as the original body, so capture doesn't occur.

## Atmospheric Slowdown of Very Small Particles

The only approach that seems to work is the capture of very small (sub-micrometre) particles into orbit around the Earth due to atmospheric slowdown. The particles are sufficiently small for atmospheric drag to be effected without excessive heating. This is connected to an area of increasing interest to astronomers, so there is considerable published material applicable to my thesis.

Related space exploration started approximately 30 years ago with measurements of dust flux in the near-Earth environment by the HEOS-2, Prospero, and Elektron-1 and Elektron-3 satellites. The key finding from these satellites was surprising: much larger densities of sub-micrometre dust particles were found in the near-Earth region than in general interplanetary space [91]. An important conclusion reached from these near-Earth dust flux measurements is that although larger objects will burn up before braking to capture velocity can be achieved, very small particles can be captured intact into Earth orbit. Bronshten [92] has generated the parameter relationships in Table 1 to explain the anomalous sky luminescence following the Tunguska meteoroid fall. He concludes that the sky glow came from sub-micrometre particles captured in the upper atmosphere.

From the table, the capture altitude region extends from 96-181km. As these smaller particles pass tangentially by the Earth, depending on their mass, there is a 'capture corridor' for each size of particle corresponding to a specific height above the Earth, in which particles of that size would be captured into a circular orbit. Below this corridor, those specific particles would enter the Earth's atmosphere and begin to settle. Above the corridor, the particles would be braked only slightly and would either continue on in space or follow an elliptical orbit, returning back to Earth at a later time. Although the corridor height and width vary greatly with particle mass, the two parameters are relatively insensitive to particle velocity. McDonnell and Radcliff have conducted the same analysis with resultant corridor heights about 40km higher, probably due to a different assumption on particle density [93].

Table 1: Capture Corridors for Small Particles

| Mass of Particles (g) | Height of Middle of Corridor (km) | Width of Corridor (km) |
|---|---|---|
| $10^{-13}$ | 181 | 8 |
| $10^{-12}$ | 158 | 7 |
| $10^{-11}$ | 141 | 5 |
| $10^{-10}$ | 128 | 4 |
| $10^{-9}$ | 118 | 3 |
| $10^{-8}$ | 109 | 2 |
| $10^{-7}$ | 102 | 1.5 |
| $10^{-6}$ | 99 | 1.4 |
| $10^{-5}$ | 96 | 1.3 |

Although orbital capture has been shown to be realistic, a severe problem still remains. Particles in approximate circular orbits would be subjected to continuing atmospheric braking, so they would not survive a single orbit. Even particles on elliptical orbits would theoretically return to their original perigees in the capture corridor each time around, where they would undergo further braking; and their lifetimes would consequently also be short.

## Particle Fragmentation

The answer to the problem could be particle fragmentation along the orbit some time after capture, on those particles captured into an elliptical orbit. As the particle travels along the ellipse to a higher altitude, it would fragment and at least some of the particles would be given appropriate incremental velocities so that their new orbits would have perigees (minimum orbital altitudes) higher than the capture altitude. The new orbits would then avoid further braking (or at least encounter significantly reduced braking), so that the particles could then exist in a relatively stable orbit.

There is a general recognition that cometary meteoroids have a density much less than water and are extremely fragile, having essentially the same composition as the parent comet. Verniani makes a typical statement: 'Most meteors are of cometary origin and are porous, crumbly objects composed of loosely conglomerate, spongelike material' [94]. This composition is susceptible to fragmentation even under very low pressures.

Jacchia further discusses the mechanism of 'successive fragmentation'. He states that 'the average meteor may be visualized as having a very porous and fragile structure ... Fragments can be detached from the surface of larger meteor bodies without destroying their unity, but if fragments of similar size are detached from small bodies, this may mean their complete disrupture into a cluster of fragments ... (Furthermore) fragmentation is not a sporadic phenomenon, but rather the rule, and for faint meteors, the classical concept of a single-body meteor must be replaced with that of a cluster of breaking fragments' [95].

Fragmentation of meteors has also been recently investigated in detail by means of the 'method of instantaneous exposure': Exposure times of $10^{-3}$ to $10^{-4}$ sec allow the photographing of the instantaneous structure of the luminous phenomena and its variations along the meteor trajectory. Pictures show the progressive disintegration into fragments of the original meteoroids. The size of the meteoroids is generally in the order of 100 micrometres (m) in radius ($10^{-5}$ to $10^{-6}$g), although one team of investigators has come to the conclusion that the size is between 0·01-0·1m [96].

Definitive support comes from the previously mentioned HEOS, Prospero and Elektron satellites. A further finding from these satellites was that the near-Earth sub-micrometre meteoric matter was not uniformly distributed, but existed as aggregations ('swarms') of particles moving around the Earth in more or less stable orbits at certain distances from the Earth's surface, as great as 10 Earth radii (60,000km). These 'swarms' made up an appreciable part of the total near-Earth dust environment [97]. Based on separation velocities, the lifetimes of the swarms (in terms of particle association) was estimated to be in the order of hours or days at the most, implying that the creation of the swarms by some sort of fragmentation was a continuing process [98].

At lower altitudes, a large number of cometary meteoroid trails in the atmosphere exhibit characteristics which can be explained by the phenomenon of successive fragmentation and

differential deceleration among fragments of different sizes. Opik in 1955 studied records of visual meteors and came to the conclusion that most visual meteors should be crumbly objects which begin disintegrating at an aerodynamic pressure of about 1kN/m² (i.e. 0·01 atmosphere). McKinley agreed by stating that 'practically all dust balls' - which is to say almost all meteors - are now thought to break up into grains when the aerodynamic drag reaches a value of about 2kN/m² (approximately 0·02 atmosphere). The effective density of the parent meteoroid is assumed to be of the order of 0·5-5 kg/m³ [99].

The altitude corresponding to 0·01 atmosphere is about 30km, which is considerably below the capture corridors in Table 1-1. However, particle collection experiments by rockets in the Earth's upper atmosphere (equal to or greater than 80km) have detected clusters of particles which suggest particle breakup at much higher altitudes. The Gemini cosmic dust experiment (S-12) obtained similar results at an altitude of 230km, indicating fragmentation at an even higher altitude. The Skylab cosmic dust experiment (S-149) had similar results at 430km. The high sensitivity Prospero micrometeorite detection experiment has found evidence of clusters of sub-micrometre particles at altitudes ranging from 547 to 1582km [100]. The supposition is then that if perigee (corresponding to the height of the capture corridor in Table 1) was initially in the region of 100-150km, than fragmentation could have occurred afterwards at higher altitudes. As discussed a little later, fragmentation might also occur at 60,000km based on electrostatic effects.

## Fragmentation Mechanisms And Velocities

Thus both Earth orbital capture and later fragmentation may be viable. The next question concerns the magnitude of the fragmentation velocity required to bring at least some of the particles into a stable orbit where the returning perigee would be above the capture corridor.

Consider a proposed mechanism for producing comet outbursts or 'jets' [101], observed in many comets. A number of studies show that at the low temperatures of space, amorphous ice is formed as one of the constituents of the cometary nucleus (which would presumably also exist in the ejected meteoroids). As the temperature increases slightly, there is a transition from amorphous ice to cubic (crystalline) ice which releases energy in the form of heat. Therefore, once the process is started, it proceeds rapidly by positive feedback, allowing other ice to change from amorphous to cubic form. Importantly, the density decreases by a factor of two in this process, doubling the volume and causing physical stress. The suddenness of the process causes pulverisation. Analysis shows that typically the largest particles would be about 10m, with a large proportion of particles in the sub-micrometre region. This phenomenon, causing cometary jets, has been determined to have occurred at about 2·5 AU, which is the distance that theory would allow it to happen. This would be true if the surface was amorphous ice; an insulating layer would move the reaction closer to the Sun [102]. Importantly, Sekanina has estimated ejection velocities in excess of 1km/s [103].

Another mechanism is electrostatic fragmentation. This type of fragmentation is likely to occur when the particle passes through regions of enhanced auroral zone electron fluxes at about 10 Earth radii (60,000km). Fragmentation down to the smallest (sub-micrometre) units is said to proceed rapidly once a large conglomerate particle enters the magnetosphere. Similar to atmospheric fragmentation, separation velocity due to electrostatic repulsion has been estimated at about 1km/s [104]. As discussed later, the ring is described in myths as having a sufficiently high inclination so that the particles would travel through the auroral zone.

11

The 1km/s fragmentation velocity parameter is important in that it is significant when compared with particle orbital velocities. The orbital velocity of a particle travelling in a circular orbit around the Earth at an altitude of the capture corridor is about 8km/s, so a 1km/s change in velocity makes a big difference. For fragmentation somewhere along the orbit after perigee, within hundreds of kilometres in altitude, a portion of the particles will settle in the atmosphere but a portion of them would have their orbits changed so that returning perigee would be above the capture corridor.

The two estimates of 1km/s separation velocity appear to be substantiated by actual measurement. On Aug. 8, 1965, in Odessa, a photograph of a bright meteor was obtained with a velocity at the beginning of the path of 20km/s. At a height of 73km, the meteoric body disintegrated into two parts. The fragmentation was in the form of an explosion, the velocity of one fragment being $1·37 \pm 0·30$km/s greater and the other $1·28 \pm 0·30$km/s smaller than the velocity of the parent body [105].

## Particle Visibility

The next important requirement on the particles is that they be observable from the earth. Sub-micrometre particles are important to my thesis since these size particles are visible due to Mie scattering of Solar radiation [106]. For example, the dust observed in the coma and dust tail of a comet is mostly of the dimensions of a few tenths of a m, simply because particles of this size range scatter optical sunlight effectively [107]. Particles having a radius less than 0·4m scatter light in the blue region extending to the ultra-violet, whereas particles having radii between 0·4 and 0·8m scatter light in the red region. Particles smaller than 0·1 micrometre or larger than 0·8 micrometre either reflect Solar radiation to a much smaller degree or obstruct it respectively. Happily, the sub-m particles having a mass from $10^{-13}$ to $10^{-10}$ grams correspond to sub-m particles in the light scattering region.

An accompanying comment is on ice particles making up the ring. Frozen gas compounds, primarily water, form a major part of the comet nucleus. Meteoric particles, consequently, would be made up of ice as well as dust particles. The reflection of Solar radiation from the ice particles would enhance the visibility of the ring as seen from the Earth.

Ice particles have appeared in interplanetary space in significant quantities. In the case of the Pioneer 10 meteoroid penetration sensor, the conclusion is that many, if not most, of the penetrations beyond 2 AU from the Sun were ice particles [108]. Importantly, the lifetime of pure ice grains is more than 1000 days at a range of one AU (the distance of the Earth from the Sun) [109]. The ice grains then could conceivably have been a part of the ring.
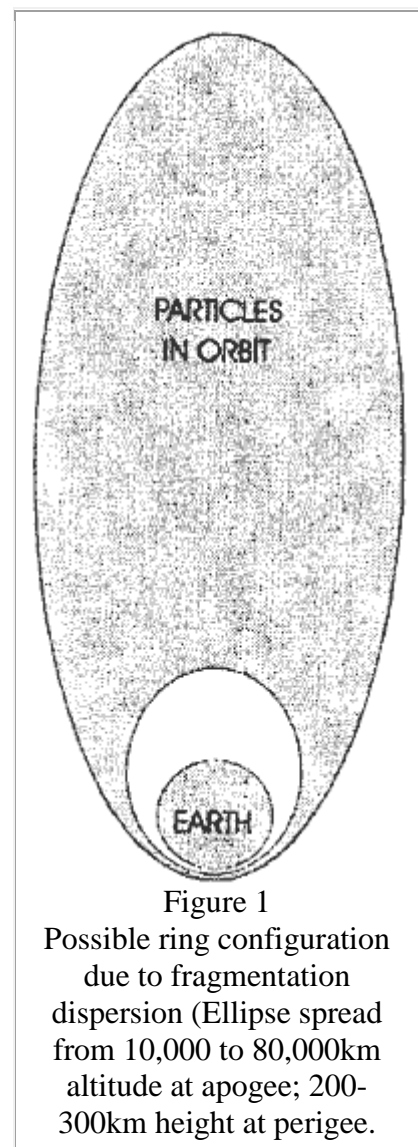


Figure 1
Possible ring configuration due to fragmentation dispersion (Ellipse spread from 10,000 to 80,000km altitude at apogee; 200-300km height at perigee.

## Ring Configuration

So far in the discussion, I have repeatedly referred to the formation of a 'ring' around the Earth. It should be understood, however, that it would not be an idealised narrow circular ring. Firstly, the particle orbits would tend to be elliptical rather than circular. Secondly, the spread of velocity magnitudes and directions due to fragmentation would result in a spread of elliptical orbits. A very simplified representation of the elliptical orbits is shown in Figure 1. The assumption is made that the debris travelled tangentially into the capture corridor in the south Polar region and then fragmented later as it travelled away from the perigee position, resulting in a spread of elliptical orbits to the north. The mythology strongly favours the apogee (maximum distance from the Earth) being in the north. Furthermore, there will also be a spread in inclination angle, so that the particles in the elliptical orbits would not be travelling in the same plane. Also, the pattern would not be homogeneous and smooth but would be somewhat ragged and differing in density from one place to another.

## Simulation Of Elliptical Ring Formation

A simulation programme has been generated to provide some degree of verification to the above proposed concepts [110]. The simulation programme supports the thesis in two critical respects:

(i) a substantial number of particles can be placed in stable Earth orbits with a modest fragmentation velocity and

(ii) the ring around the Earth could be formed in hours after initial capture and first orbit fragmentation.

Four quantities are entered into the programme: the initial minimum height and maximum height of the orbit above the surface of the Earth, the time of fragmentation after passing perigee and fragmentation velocity. Fragmentation consists of a very large number of particles travelling in random directions from the point of fragmentation. A new orbit is then computed for each individual particle; the principal computed orbital parameters are the final minimum and maximum distances from Earth's surface (perigee and apogee). The main conclusions of the simulation program as well as general observations are as follows.

1. The resultant returning perigee cannot be above the altitude of fragmentation. Consequently, if returning perigee must be above 200km, then fragmentation must also be above that altitude. If the Gemini, Skylab and Prospero measurements are valid, then this high altitude fragmentation is possible.

Another factor might assist the higher altitude fragmentation: the transformation process from amorphous to crystalline ice resulting in the fragmentation releases energy in the form of heat; this provides a positive feedback which continues the process [111]. One might speculate that fragmentation which started at a lower altitude might then continue to higher altitudes. The single fragmentation executed in the simulation programme might then be a pessimistic case.

2. Although results do vary to some extent with initial maximum height, with an initial perigee of 100km and a fragmentation height above 200km, then approximately 20% of the particles will have stable orbits having a minimum height greater than 200km. This is a very

13

respectable portion of the total debris that may have been initially captured. Furthermore, this is accomplished with a separation velocity of only 500-600m/s, approximately half of the earlier given value of 1km/s.

3. The proportion of particles on stable orbits and the final minimum height (at perigee) are fairly insensitive to fragmentation velocity, which has its greatest effect on maximum height at apogee. A 500m/s separation velocity can produce a range of thousands of km in orbital maximum heights above the Earth's surface.

4. Although apogee heights vary greatly, there is no significant variation in the angular direction of apogee for the resultant particle orbits. In other words, maximum height for all particles would exist to the north (with minimum height - perigee - being to the south).

5. For a 500m/s separation velocity, there would be an approximate resultant 7° spread in inclination angle of the particle orbits. This has a smaller (but still noticeable) impact on the ring's appearance from the Earth than the variation in maximum height.

6. Since the orbital period (time for complete travel around the Earth) is closely related to the maximum height of the orbit, the orbital periods would vary over a wide range. E.g. two orbits with heights of 10,000 and 80,000km would have periods of 2·5 and 27·5 hours respectively. This means that the ring could have formed around the Earth in a matter of hours, corroborating the mythologies.

Obviously, I have no idea of the actual distribution of meteoroid debris travelling through the capture corridor, capture velocities, fragmentations along the orbit, fragmentation velocities, magnitude or direction. The simulation programme provides good verification to the concept based on representative fragmentation velocities at designated locations after perigee. However, more realistically, continuous fragmentation along the orbit would occur and even fragmentation during many orbits after initial capture. For very large orbits, electrostatic fragmentation due to passage through the auroral zone would also be possible. The resultant ring formation would, of course, be impossible to predict. The important issue is that a feasible mechanism has been identified for short-term ring formation.

## Observation Of The Ring

The inclination of the ring is the most important parameter. A 70° inclination ring surrounding the Earth is shown in Fig. 2. This is a very idealised picture, since it does not take into account the multi-elliptical nature of the ring depicted earlier in Fig. 1; it is intended only to provide some insight into the following discussion and associated figures. In Fig. 3, the ring is shown as it would be projected on to the Earth at a particular point in time. The maximum northern and southern extensions of the projection are at 70°N and S respectively. The equator is represented by the solid horizontal line. A horizontal dashed line is at 30°N, where observers in the most advanced cultures were generally located.

It is important to understand that although the ring moved with the Earth as it circled the Sun, the ring's orientation would be stationary in space with the Earth rotating under it. The following conditions would exist for one point in time for four sets of observers on the Earth, separated by 90° in latitude. For observers in the Pacific Ocean,



Figure 2 Simplified picture of the ring having a 70° inclination angle surrounding the Earth

the ring would be seen extending overhead from northwest to the southeast. For observers in Asia, the ring would appear in the north. In the Mediterranean region, the observers would perceive the ring as extending overhead from the northeast to the southwest. Observers in the southern part of North America would see the ring as extending to the south. As will be shown shortly, these observers would not see the southernmost portion of the ring because of their northern latitude.

For a single viewer at a specific location, the ring would appear to move from east to west as the Earth rotated on its axis, so the ring would first extend from northwest to southeast, then swing around the south, then extend from northeast to southwest, and then swing around to the north. The ring must have been awe-inspiring to observers on the ground. In addition to its overbearing appearance, it did not simply swing by overhead - it changed orientation over a 24hr period. It worth trying to show what an observer on the ground would have seen as he looked up at the sky.

A computer simulation of the ring observed with time in three-dimensional space from a single observation point is shown in the four diagrams in Figure 4 over a 24hr period [112]. The concentric circles going out from the centre dot represent 60°, 30° and 0° elevation angles (looking at the horizon) respectively. The dot in the centre represents the viewer looking directly overhead (90° elevation angle). The time sequence starts with Diagram A (1-6hrs), and then travels clockwise through Diagram B (7-12hrs, Diagram C (13-18hrs) and Diagram D (19-24hrs). The successive positions of the ring represent one-hour intervals to an observer at 30°N latitude. In Figure 4A, the ring first appears on the horizon in the east, moves until it extends all along the eastern horizon and then begins to swing around to a northeast to
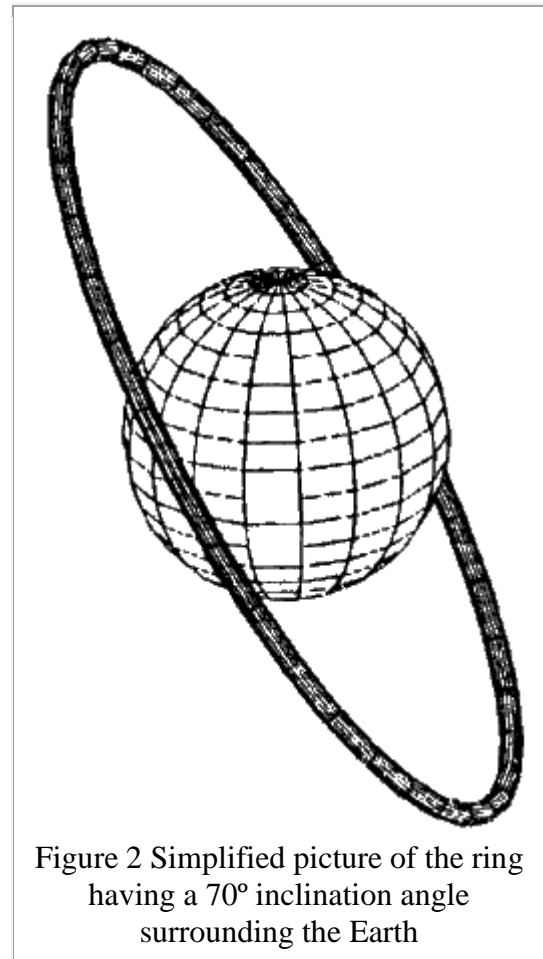
15

southwest direction. Figure 4B starts where Figure 4A leaves off. In this figure, the ring continues to swing around past the overhead position until it extends in the north from east to west. Continuing in Figure 4C, the ring swings down until it now extends from the northwest to the southeast and then continues to move westward. In Figure 4D, the ring continues until it extends along the western horizon and then disappears in the west. At that time, the other side of the ring would then appear in the east and the cycle would start over again.

Rather than being a circle, the representative orbit has been taken from the earlier discussion as an ellipse, with perigee to the south, about 200km height and the apogee to the north, 60,000km height. The appearance of the ring changes to some extent with altitude but doesn't affect the basic visual story.

The cultural areas at 2300 BC extended essentially from 20° to 40°N latitude, with Scandinavian, northern central Asian and northern North American cultural areas extending as far as 65°N. For the more northern cultural areas, the pattern would shift to the south; accordingly, the pattern would shift to the north for the more southerly cultural areas.
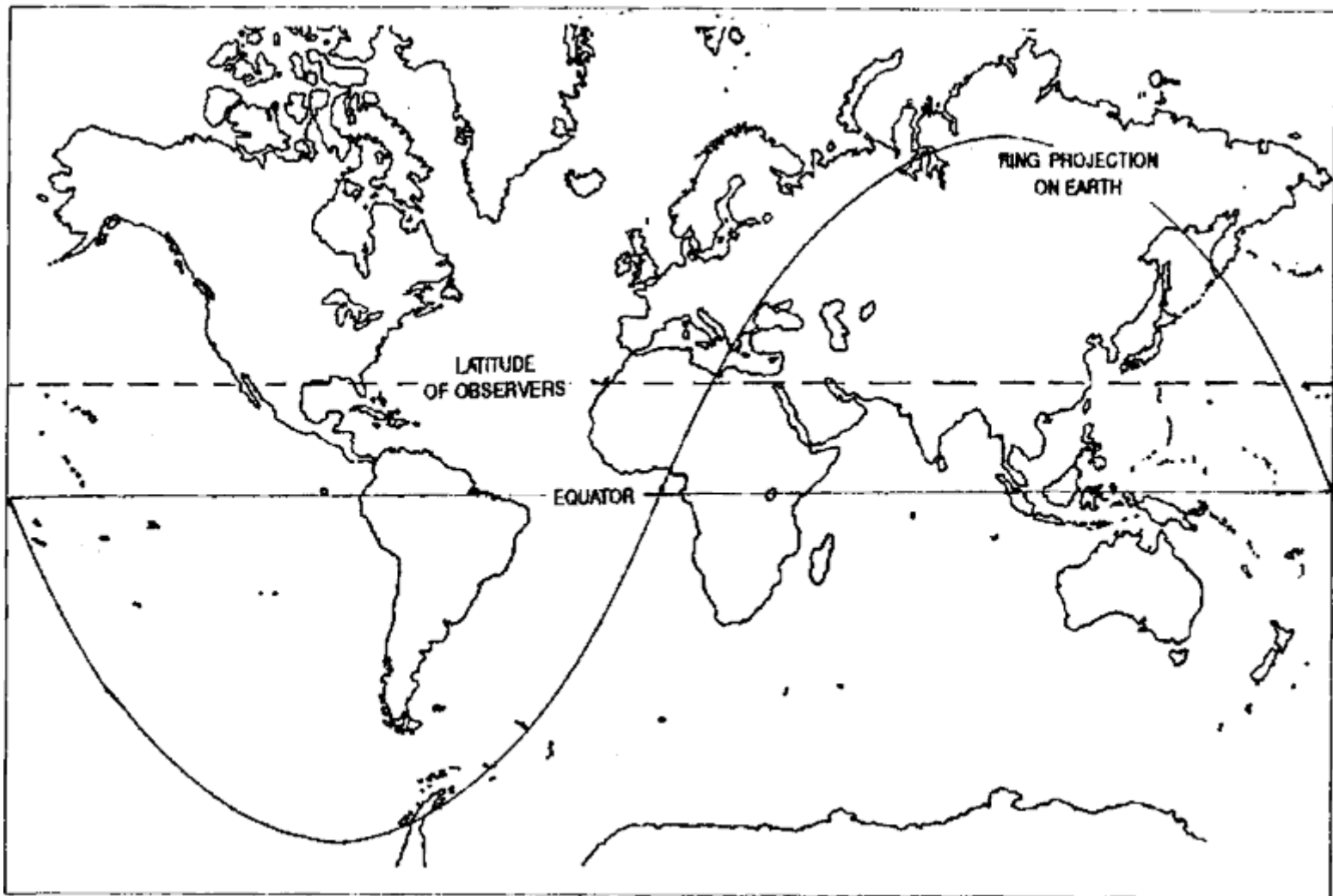


**Figure 3 The 70º inclination ring projected on to the Earth**

Let us now take one further step. Earlier, I mentioned that the ring was likely to be made of particles travelling on different orbits, typified by the spread of ellipses in Figure 1, where the maximum and minimum heights from the Earth's surface at apogee were arbitrarily selected

16

as 80,000km and 10,000km respectively. Figure 5 shows what the circle would look like at three different positions at 2·5hr intervals, corresponding to Figure 4. As you would expect, the circle would have the narrowest aspect when directly overhead, since the observer would see the orbits mainly in their plane of rotation. As the 'circle' moved away from overhead, the ring would be seen to broaden. However, it would always be viewed as a surrounding phenomenon.

As mentioned earlier, there is also an orthogonal spread to the altitude regime due to variation in inclination angle, so the actual ring, in addition to being a pattern as shown in the earlier Figure 1, would have a thin elongated elliptical cross-section and would also be heterogeneous in appearance.

As previously stated, the ring orientation was stationary in space. The ring would travel with the Earth around the Sun but its angular orientation in space would remain constant. This means that the same stars and constellations would always be seen in the sky near the ring. In general, the ring would appear to travel across the sky along with the stars at night and with the sun during the day.

I have no idea of how long the ring remained around the Earth. I assume that it was relatively short (weeks or months) since I have found no reference to the specific time when it disappeared. The oblateness of the Earth, lunar gravitational influence and electromagnetic effects on the likely charged particles in the stream would all work towards gradual dispersion. Regardless of how long it lasted, the ring must have made a dramatic impression on all peoples on the globe, judging from the tremendous body of mythology pertaining to it.
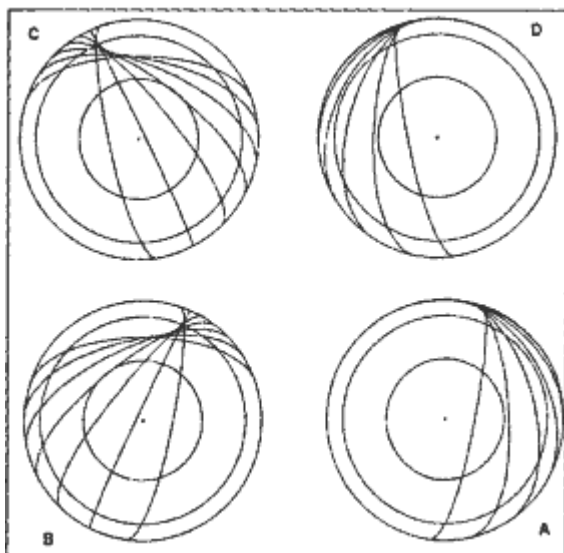


Figure 4 The ring aligned on a 70º inclination orbit as viewed by an observer at 30ºN latitude. Diagrams A, B, C and D show successive viewed positions of the ring through a 24hr period. The centre dot and concentric circles represent 90º, 60º, 30º and 0º elevation angles respectively.
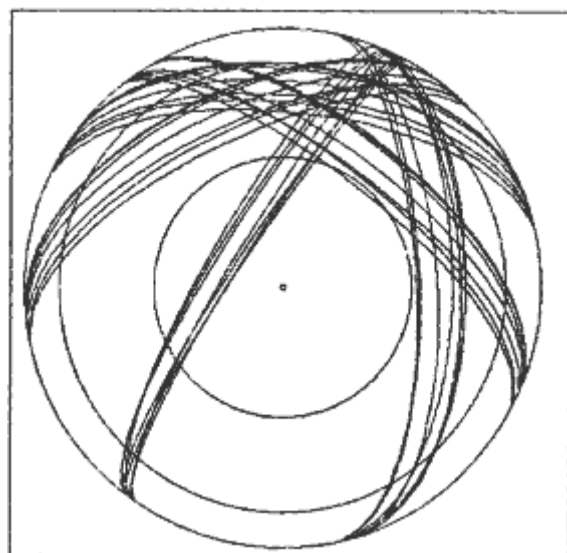
Figure 5 Appearance of ring at 2·5hr intervals assuming particles extending from 10,000km to 80,000km above the Earth's surface at apogee.

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110. This program, written in FORTRAN, is one of two simulation programs introduced in this paper. Both programs were initially developed by Mike Menzel. He and Roy Tangradi gave me valuable guidance in astrodynamics, for which I am very appreciative.

111. H Patashnick, G Rupprecht, DW Schuerman, 'Energy Source for Comet Outbursts', *Nature* Vol. 250 (1974), pp. 313, 314.

112. This second simulation program is written in BASIC.