Table of Babylonian/Greek/Roman Theories of Comets

<table>
<thead>
<tr>
<th>Date</th>
<th>Broad Type</th>
<th>Originator</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>c.2000 BC</td>
<td>Celestial</td>
<td>Babylonians</td>
<td>Earthly bodies akin to planets</td>
</tr>
<tr>
<td>c.3000 BC</td>
<td>Celestial</td>
<td>Babylonians</td>
<td>Fiery celestial phenomena</td>
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<tr>
<td>c.575 BC</td>
<td>Celestial</td>
<td>Anaximander</td>
<td>Jets from fiery celestial hoops</td>
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<tr>
<td>c.350 BC</td>
<td>Atmospheric</td>
<td>Xenophanes</td>
<td>Burning planets</td>
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<tr>
<td>c.450 BC</td>
<td>Celestial</td>
<td>Anaxagoras</td>
<td>Planetary ‘ conjunctions’ on sky</td>
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<tr>
<td>c.450 BC</td>
<td>Celestial</td>
<td>Pythagoreans</td>
<td>Rare sighting of a planet</td>
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<tr>
<td>c.430 BC</td>
<td>Celestial</td>
<td>Hippocrates</td>
<td>A kind of planet</td>
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<tr>
<td>c.430 BC</td>
<td>Atmospheric</td>
<td>Pythagoreans</td>
<td>Reflected sunlight</td>
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<tr>
<td>c.430 BC</td>
<td>Celestial</td>
<td>Diogenes</td>
<td>Chains of rocky bodies (stars)</td>
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<td>c.400 BC</td>
<td>Celestial</td>
<td>Aratos</td>
<td>Chains of unseen planets</td>
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<tr>
<td>c.350 BC</td>
<td>Atmospheric</td>
<td>Aristotle</td>
<td>Fiery atmospheric phenomena</td>
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<tr>
<td>c.350 BC</td>
<td>Atmospheric</td>
<td>Heraldeides</td>
<td>Reflections from high clouds</td>
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<td>c.330 BC</td>
<td>Atmospheric</td>
<td>Meroedorus</td>
<td>Influx of Sun into clouds</td>
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<tr>
<td>c.330 BC</td>
<td>Celestial</td>
<td>Apollonius</td>
<td>Celestial bodies</td>
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<tr>
<td>c.300 BC</td>
<td>Celestial</td>
<td>Zeos</td>
<td>Conjunctions of stars</td>
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<td>c.200 BC</td>
<td>Celestial</td>
<td>Stratos</td>
<td>Stars enveloped by cloud</td>
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<td>c.130 BC</td>
<td>Atmospheric</td>
<td>Panaites</td>
<td>False images of stars</td>
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<tr>
<td>c.100 BC</td>
<td>Atmospheric</td>
<td>Biceclus</td>
<td>Violent, fiery winds</td>
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<tr>
<td>50 AD</td>
<td>Celestial</td>
<td>Seneca</td>
<td>Celestial bodies</td>
</tr>
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</table>
Later Developments of Astronomy

3. Horoscopic Astrology (=400 BC to ~1600 AD)
   - Based on the entirely false premise that wandering stars (‘planets’) exert a distant controlling influence on human affairs.
   - Provides an early example of a powerful, but ‘magical’ scientific concept, i.e. ‘action at a distance’.
   - Motivates careful observations of the planets; their paths against the fixed stars; their periods of revolution etc. all linked to predictions.
   - Demonstrates growing understanding and an increasingly ‘scientific’ approach to observers of the natural world.
   - Nevertheless, the focus on unimportant chance alignments of planets and stars, planetary conjunctions etc. (e.g. ‘Star of Bethlehem’), and on the ‘random’ appearance of an occasional bright comet etc. ultimately proves to be a cul-de-sac for science.
   - Despite this, the idea of horoscopic astrology has proved remarkably hard to shift: it’s still believed by upwards of 25% of the population.

4. Scientific Astronomy (~1600 AD to present)

Comets and Meteors as Omens or Prophecies

1. Precise astronomical observations were the key to prophecies; and the omen literature always took the form: “If [astronomical observation] then [prophetic effect].” E.g., quoted by Björkman (Meteoritics, 8, 91, 1973): “A shooting star flashes as bright as a light or as a torch from east to west and disappears on the horizon, then the army of the enemy will be slain in its onslaught.”

2. Some early cometary observations are quoted by Olivier (in “Comets”, 1930). Thus, on a Babylonian tablet dated around 1140 BC and referring to a military campaign, we read: “a comet arose whose body was bright like the day, while from its luminous body a tail extended, like the sting of a scorpion.” And in Diodorus Siculus’s account of the expedition of Timoleon (344 BC): “On the departure of the expedition of Timoleon from Corinth to Sicily the gods announced his success and future greatness by an extraordinary prodigy. A burning torch appeared in the heavens for an entire night, and went before the fleet to Sicily.”

What could have led to these ideas? Seneca (c.4 BC – 65 AD) gives some insight. Referring to the ‘difference’ between us Romans and Etruscans, he remarks: “We believe that lightning is caused by clouds colliding, whereas they believe that clouds collide in order to create lightning. Since they attribute everything to the gods, they are led to believe not that events have a meaning because they have happened, but that they happen in order to express a meaning.”

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Chinese/Greek/Roman Classification of Comets

Cometary forms. Left: Chinese classification c.168 BC (Xi Ze-song, 1884) and Comet of 1577 (M. Dizer, Kandili Observatory). Centre and Right: Greek and Roman classification schemes for comets (Halley's 1858).

Comet Images from Fifteenth to Nineteenth Century

Halley's Comet (1774, from Pernsburg Chronicle 1497); Comet Holmes (1992 November 9/10). Donald's Comet 1954 and Great Comet 1981, and Comet 1027

Great Comet of 1910: Drawing versus Photograph

The Great Comet of 1910: drawing by Eileen Havins and photograph around same time.

Comets of 1577 and 1995 Hale-Bopp (Two Prints)


17th and 19th-Century Views of Halley's Comet

Halley's Comet in 1683 (Halleyus) and in 1835/36 (Smirnovschei).

Impacts Occur: 20th Century Examples

Left: The 1908 Tunguska event in Siberia on June 30 (Kutik), compared with the tree-fall pattern superimposed over London (J. Tate). Right: Sikhote-Alin meteorite (Courtesy Russian Academy of Sciences).

Effects of Impacts: Great and Small

Impacts can produce effects ranging from mass-extinctions of life (e.g. K/T boundary c.65 Myr ago) to merely local damage (e.g. Sikhote-Alin meteorite, 1947). They can also lead to new mythology and superstition (e.g. the erection of a totem pole at the Tunguska ground-zero to Agby, the Siberian god who brings fire to the forest).

Short-Term Implications

Ancient societies appear to be obsessed by the sky:

- e.g. early astronomical interest in 'the sky', evidence of megalithic monuments/prehistoric 'rock art'.
- Neugebauer: "... ancient 'astrology' can be much better compared with weather prediction from phenomena observed in the sky than with astrology in the modern sense of the word." Suggests knowledge of direct link between sky and Earth.
- Consistent with more "activity" in the sky in the distant past.
- Suggests that some solar-system phenomena may change on much shorter time-scales than we normally consider possible.
Ancient Greek Mysteries

Ancient Greek “mysteries”. Problem of Milky Way . . . Zodiacal Light?

- Anaximander: describes stars as lighted jets of gas spurting out of a punctured heap of fire.
- Aristotle: believes the Milky Way to lie in the sublunar zone, a hot accumulation of the diintegration products of many comets.
- Anaximander, Parmenides, Leucipus: the ‘stars’ lie below the Sun and the Moon.
- Meteorus and Onopiodes of Chios: the Milky Way is the former path of the Sun.
- Anaximander and Democritus: the Milky Way lies in the shadow of the Earth.

Image: Milky Way (A. White): Leontid meteor storm; and zodiacal light.

Debating Origin of Comets in Mid-17th Century

18th century sees contrast between an older ‘astrological’ view, with comets as portents of doom potentially disastrous for life on Earth; and a new ‘teleological’ view developed by Newton and his disciples, with emphasis on the providential characteristic of comets. Thus:

1. Comets supply the ‘most subtle and active parts of our air, upon which the life of things chiefly depends’ (Pemberton 1728); and comprise a ‘pure, elementary fire, of absolute necessity for the life and being of all things’ (Hale 1794).
2. Stars and planets are inhabited by living things, and comets – moving from one stellar system to another — provide the means by which stars and planets can replenish their day-to-day losses (Herschel 1780).

In contrast, the older, ‘astrological’ view persists amongst the general public:

Lines To A Comet — I (William Carleton c.1835)

Unpublished poem inspired by Halley’s Comet, 1835

Allusions to the comet as a member of the highest order of angels; as ‘long-haired’; and to the record of the four horses of the apocalypse in the Book of Revelations, the red horse that was given the power (i.e. given with the approval of God) to take peace from the Earth and to make men slay one another by the sword ...

The second verse has further allusions to the Book of Revelation, and end-times; to Homer’s Iliad (The Iliad of Achilles shown), rendered by Pope as: “Like the red star, that from his flaming hair, Shakes down diseases, and endWtimes ...” and to Milton’s Paradise Lost as: “Satan stood Unshorn, and like a Comet burn’d.” That fires the length of Ophiuchus; high in Triangulum, and from its horrid hair, Shakes pestilence and war.

Lines To A Comet — II (William Carleton c.1835)

But did death-flag so bright
Before a’er falling empires ever seen?
Given heaven a sign that man should be a slave?

No, it is freedom’s light
Streaming on high a signal for the brave
And shines not only to inspire man to
Guiding the oppressed to victory and right

The tyrant may grow pale
The light that chains the slave to him in gloom
Wants thy bright beam that wrote Behzahzar’s doom
Angel of freedom hail
When Michael’s host with thy first victory rung

There was the Battle-banner o’er them hung
Triumphant floating on the heavenly gal

Rimbardsz Behzahzar’s Feast (c.1835) Wikipedia Commons

Lines To A Comet — III (William Carleton c.1835)

Then not — Thou art like some mighty mind
That runs a bright imaginary career.
In solitary grandeur through its sphere
Too strong for laws to bind
Again I had thee mystic prince of night
Throwing so proudly every star of light
From thy own orbs of splendour far behind
Or art thou some great Power
Or high Arch-angel fallen still in quest
With troubled spirit of thy long last rest
Whom awful thoughts do mourn
Alas! what splendid misery is thine
With rain’d pale face; bright, bold thy Soul shine
Though thy fate passed th’irrevocable hour.

Lines To A Comet — IV (William Carleton c.1835)

Thus Byron rose and paced:
Like thee along his dolorous way he shone
Looking for peace unhappy and stary
His course as bright as fast
Improvisation thinks she still can view
Where he his parting blaze of glory cast
The Eagle too of France
And terror of a world Napoleon
Like thee shook guilty tyrants on their throne
With long-damning — compelling glance
He made of states and kingdoms mighty
Smears and planted freedom on their prostrate necks
Shivering their sceptres with his bolt-like lance.

New Theories for Old: Decline of Catastrophism

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Scientific Advances: Sixteenth Century and Beyond

1. Aristotelian dogma: Comets are atmospheric phenomena; the Earth is the centre of the Universe; the Moon, Sun and planets revolve around the Earth, as too do the fixed stars. The dogma persisted nearly 200 years.
2. Renaissance: Rediscovery that comet tails always point away from the Sun (Apian et al. 1540). Showed that comets are not totally unpredictable.
3. Distance: Comet of 1577 shown to be at least 6 times farther than Moon. (Tycho) — helps to undermine the Aristotelian theory.
4. Orbits: Gradual acceptance of heliocentric theory (Copernicus, Galileo) together with Kepler’s and Newton’s insights into planetary motion leads to new questions about comets. Are they ‘solar system’ or ‘interstellar’ objects; are they ‘gravitating’, and what threat do they pose to Earth in its orbit?
5. Halley’s Comet: Halley shows that the orbits of the comets seen in 1456, 1531, 1607 and 1682 are closely similar. Predicts the comet’s return in 1759, a prediction confirmed. Demonstrates that comets are indeed ‘gravitating’, matter, and at least one has a periodic orbit.

Lines To A Comet — III (William Carleton c.1835)

Allusion to comets lying beyond the Moon, as in that of 1577, i.e. passing through the crystalline spheres; and to comets as one of three principal celestial bodies (stars, planets, comets) identified by the ancients, i.e. stars, planets and comets ...

The sixth verse returns to the idea of a comet as a fundamentally benevolent being, a member of the highest order of angels, although tragically destined to die and decay.

The personification of the comet; allusions to a ‘mystic’, but ultimately troubled, career.

Finally comets signify changes in world order, exemplified by Napoleon’s belief that the comet of 1801 promised success in his invasion of Russia (when it arguably had the opposite effect). Despite benevolent tendencies, comets have a powerful influence on terrestrial affairs and remain a capricious force capable of throwing thunderbolts, and therefore of continuing concern to emperors and kings.

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Summary: Comets in Literature and Poetry

1. Virgil “At no other time did more thunderbolts fall in A clear sky, nor so often did dread comets blaze.” Georgica, Book I.
2. Homer “Like the red star, that from his flaming hair Shakes down diseases, pestilence, and war.” The Iliad.
3. Shakespeare “Comets importing change of times and states Bring forth your crystal tresses in the sky.” Henry VI.
4. Milton “Satan stood Unterrified, and like a comet burn’d That fires the length of Ophiuchus huge in th’Artick sky, and from its horrid hair Shakes pestilence and war.” Paradise Lost.

Comets as Horror-Movies: “Monstriferus” (Pliny)
Ambrose Paré (1510-1590), the father of French surgery: “The comet was so horrible, so frightful, and it produced such terror in the vulgar, that some died of fear and others fell sick. It appeared to be of excessive length and was the colour of blood At the summit of it was seen the figure of a bent arm, holding in its hand a great sword, as if about to strike. At the end of the point there were three stars. On both sides of this comet were seen a great number of axes, knives, blood-coloured swords, among which were a great number of hideous human faces, with beards and bristling hair.”

Summary Up to 18th-Century Watershed
1. Comets sometimes the most prominent objects in sky: as bright as the brightest stars. Appeared unpredictably but move like planets . . .
2. Comets and associated meteoric phenomena scrutinized as ‘comens’ to predict events on Earth; observations go back millennia.
3. Mankind’s puzzling ‘fear’ of comets still not adequately explained.
   - Historical evidence suggests the sky may have been significantly different in proto-historic times.
   - Suggests actual experience of Earth as an ‘open’ system: in touch with its near-space celestial environment.
   - But is astronomical change on such historical timescales possible?
4. Two thousand years of ‘atmospheric’ ideas finally superseded by a correct ‘celestial’ picture for comets.
5. Later — and modern — debates focus on ‘interstellar’ versus ‘solar system’ ideas, and whether comets are distinct objects in their own right, or objects with an origin more akin to planets.

Table of Cometary Theories from c.1600–1800
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<thead>
<tr>
<th>Originator and Date</th>
<th>Theory and Broad Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tycho (c.1600)</td>
<td>Comets are exhalations from planets: a ‘halfway house’ between the ‘celestial’ and ‘atmospheric’ theories</td>
</tr>
<tr>
<td>Kepler (c.1600)</td>
<td>Comets are interstellar objects; move on rectilinear paths and populate the ‘heavenly air’ in great numbers. Form from the celestial fires by process akin to cloud formation</td>
</tr>
<tr>
<td>Galileo (c.1600)</td>
<td>Last genuinely ‘atmospheric’ theory: comets are a form of reflected sunlight, akin to rainbows, parhelia etc.</td>
</tr>
<tr>
<td>Sir William Lowder and Henry Percy (c.1610)</td>
<td>Comets are exhalations from Sun: the cinder refuse from great solar conflagrations</td>
</tr>
<tr>
<td>Anon. (c.1620)</td>
<td>Comets are vapours that condensed in planetary atmospheres; ejected by violent whirlwinds into parabolic orbits</td>
</tr>
<tr>
<td>Hevelius (c.1680)</td>
<td>Comets are vapours that condensed in planetary atmospheres; ejected by violent whirlwinds into parabolic orbits</td>
</tr>
<tr>
<td>Cassini (c.1680)</td>
<td>Comets are interstellar objects: vapours ejected from stars</td>
</tr>
<tr>
<td>Halley/Newton (c.1680)</td>
<td>Comets are gravitating solar-system objects, akin to planets</td>
</tr>
<tr>
<td>Buffon (c.1745)</td>
<td>Comets akin to planets; formed as part of solar system through collision of a comet with the Sun</td>
</tr>
<tr>
<td>Kant (c.1755)</td>
<td>Nebular Hypothesis: comets, like planets, form by condensation in protosolar nebula; comets akin to planets</td>
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Acknowledgements
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