Welcome to the Professor Comet Report!
This is a monthly, bimonthly, or seasonal report on the latest information for the tracking, studying, and observation of comets. All comet reports will include tables of definitions & terminologies, basic understanding about comets, how to observer comets to the latest ephemeris data and tracking charts, photometry graphs, etc. All information within this report can freely be referenced from a table of contents. Enjoy the world of comet astronomy!
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<td>6.0</td>
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<td>Johnson</td>
<td>2015 V2</td>
<td>C</td>
<td>*9.7 (7 March)</td>
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<td>6.0</td>
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<td>5.5</td>
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<td>PanSTARRS</td>
<td>2015 ER61</td>
<td>C</td>
<td>*10.4 (8 March)</td>
<td>Brightening through May with an expected Peak brightness in Early June.</td>
<td>7.0</td>
<td>Sagittarius (23 Feb to 26 Mar) Capricornus, Aquarius, Pisces (27 Mar thru 1 June)</td>
<td>Fixed Early Morning (1 March – Early Summer)</td>
<td>Fixed Early Morning (1 March – Early Summer)</td>
<td>Observable by Early April and before midnight by mid September!</td>
</tr>
<tr>
<td>Honda – Mrkos - Pajdusakova</td>
<td>45P</td>
<td>P</td>
<td>*10.5 (8 March)</td>
<td>Fading from its peak brightness back on 11 Februa.</td>
<td>6.7</td>
<td>Mostly Leo (25 Feb to 25 June) Leo Minor (2 – 4, 7 – 12 Mar)</td>
<td>Morning (Early Feb to Late Mar) Before Midnight (After 20 Mar)</td>
<td>Morning (Early Feb to Late Mar) Before Midnight (After 20 Mar)</td>
<td>Continues to be observable at Mag &gt; 13.0 until Early May!</td>
</tr>
<tr>
<td>NEOWISE</td>
<td>2016 U1</td>
<td>C</td>
<td>11</td>
<td>Fading from peak Brightness in Mid January.</td>
<td>6.1</td>
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<td>Unobservable (Visual Mag &gt; 18.0)</td>
<td>Unobservable (Visual Mag &gt; 18.0)</td>
</tr>
<tr>
<td>Schwassmann – Wachmann 3</td>
<td>73P</td>
<td>P</td>
<td>12.5</td>
<td>Three known fragments in existence: (C, B, &amp; BT)</td>
<td>12 -12.5</td>
<td>Summer to Autumn Skies (1 Jan to 1 June)</td>
<td>Morning (1 Jan to 6 Mar) Before 5:45 am CST</td>
<td>Morning (1 Jan to 6 Mar) Before 5:45 am CST</td>
<td>Observer only at very, low horizons.</td>
</tr>
<tr>
<td>PanSTARRS</td>
<td>2016 R2</td>
<td>C</td>
<td>13</td>
<td>Brightening, but no observations yet! (Expected Peak in January 2018)</td>
<td>10</td>
<td>Fornax (1 Jan to 5 March) Eridanus (6 March to 1 June)</td>
<td>Early Evening (1 Jan to 25 March)</td>
<td>Early Evening (1 Jan to 25 March)</td>
<td>Observable at low horizons in the SW just after sunset!</td>
</tr>
<tr>
<td>LENEOS</td>
<td>315P</td>
<td>P</td>
<td>13</td>
<td>Holding Steady in Brightness peak is predicted for mid Spring.</td>
<td>14.2</td>
<td>Leo, Coma Berenices, Ursa Major (1 Jan to 1 June)</td>
<td>Mid Evening to Early Morning (1 Jan to 1 June)</td>
<td>Mid Evening to Early Morning (1 Jan to 1 June)</td>
<td>Night time, but set earlier with each following day!</td>
</tr>
<tr>
<td>Hartley 2</td>
<td>103P</td>
<td>P</td>
<td>13.3</td>
<td>Lost in the Daytime glare (Solar Elongation is less than 10°)</td>
<td>10</td>
<td>Not observable until Late September</td>
<td>Unobservable (Visual Mag &gt; 17.5)</td>
<td>Unobservable (Visual Mag &gt; 17.5)</td>
<td>Unobservable (Visual Mag &gt; 17.5)</td>
</tr>
</tbody>
</table>

*Lost in the Daytime Glare!*

- ††38° N - 72° S  
  Summer to Autumn Skies (1 Jan to 1 June) 
  Morning (1 Jan to 6 Mar) Before 5:45 am CST  
  Observer only at very, low horizons.
- ††47° N - 67° S  
  Fornax (1 Jan to 5 March) Eridanus (6 March to 1 June) 
  Early Evening (1 Jan to 25 March) 
  Observable at low horizons in the SW just after sunset!
- 78° N - 48° S  
  Leo, Coma Berenices, Ursa Major (1 Jan to 1 June) 
  Mid Evening to Early Morning (1 Jan to 1 June) 
  Night time, but set earlier with each following day!

**Not observable on the celestial prime meridian for most or all of 2017!**

*Not observable at zenith since the comet is lost in the daytime glare either before sunset or sunrise.*

*Visual Mag. Value is given based on the latest observation field report!*

**Comets that are only visible in the most southerly regions of the US and corresponding territories or visible only to observers in the Southern Hemisphere!**

*This spreadsheet table of data is applied only to bright comets defined by observable stellar magnitudes greater than 13.5 or 14.0 in times of sparingly available comets for observation!***
WHAT ARE COMETS?

- Comets are known as minor planets like asteroids or other small space debris.
- Bodies composed of metals (rocks), dust, & volatiles (examples: CO\textsubscript{2}, H\textsubscript{2}O, CN\textsuperscript{-}, C\textsubscript{2}, C\textsubscript{3}, CS, COS, HO\textsuperscript{-}, etc.)
- Frozen bodies of Dirty Ice (Asteroids coated in and Saturated with Icy Volatiles)!
- Clathrytes are minerals & denser ices containing less dense volatiles imbedded within the crystal structure of the materials.
- Comets are composed of three primary elements: (central nucleus, coma, and tail(s))
- The central nucleus can range anywhere in size from a few meters across and up to tens of kilometers across.
WHAT ARE COMETS?

- They have no moons or rings.
- The coma can reach from a few thousands and up to over 2 million km across (example: 17P/Holmes).
- The tails can extend past 900,000 km in length can could theoretically extend up to 1 AU!
- The material from the dust tail is the primary, but not the only source of micrometeoroids for meteor showers.
- Their origin lies beyond the planets of the solar system to the Kuiper Belt & Oort Cloud.
- Short period comets (less than 200 years) from the Kuiper Belt & longer period comets (greater than 200 years) come from the Oort Cloud. Jupiter Comets (~3 to 20 years).
- Rotational period of cometary nuclei can vary substantially from a few seconds to several days!
WHERE DO THEY COME FROM?

*Kuiper Belt*

Source of all short period comets that extends from the orbit of Neptune (30 AU) and out to about 50 AU from the Sun. It is just like the Asteroid Belt in structure, but 20x wider and upwards up 20x – 200x the mass. Many of the more massive bodies that came from the Oort cloud end up residing inside the Kuiper belt. These are huge icy bodies composed of the same or similar substances as the comets. About 100 000 KBOs up to 100 km across are hypothesized to exist with this region of the solar system.
WHERE DO THEY COME FROM?

Scattered Disk Region

This is an intermediate region between the outer edge of the Kuiper Belt and the inner edge of the Oort Cloud. This region of the solar system lies beyond the Heliopause and contains very few icy bodies which many are nearly on the same or similar scale of Pluto & Triton (Neptune's moon) in terms of size, mass, composition, & density! The orbital distances can overlap with the innermost regions of the Kuiper belt, but some of these known objects discovered due can venture out to distances up to 500 AU and quite possibly further! Large orbital eccentricities and high orbital inclinations; up to 0.8 & 40° respectfully.

Over 200 have been identified officially as of 2011!
WHERE DO THEY COME FROM?

**Oort or Öpik – Oort Cloud**

Oort cloud is the source of all intermediate and long period comets that extend from 2,000 AU and up to about 3.16 light years from the Sun. The Inner Oort cloud would contain the intermediate period comets while the long period comets & great comets would originate from the outer Oort cloud. Estimations on the number of cometary bodies vary substantially from several hundred billion to upwards of 2 trillion icy minor planets! All of the largest icy bodies in the solar system would have originated from this region of the solar system (example: Plutinos, Trans – Neptunian Objects, Scattered Disk Objects, comet nuclei up to 60 km across in size. Tidal gravitation forces from neighboring stars and density variations within region to region within the milky way galaxy plane would force these objects to orbits closer to the Sun!
WHERE DO THEY COME FROM?

**Jovian (Jupiter) Family of Comets**

These are nearby comets that reside between the boundary of the inner and outer planetary solar system with orbital periods between 3 – 20 years. Their current orbits are influenced by the strong gravitational field of Jupiter which can adjust all or most of the orbital parameters of these bodies are their farthest positions of influence from the Sun’s gravity. It is likely that all of these objects where broken off from the larger icy – rock bodies of the Kuiper Belt during large orbital or non – orbital paths about the Sun in highly eccentric orbits due to the gravitational influence of Neptune upon close approach to that planet!

Unlike the longer – periodic comets these bodies have shallower orbital inclinations ≤ 18⁰ and orbit in the same direction as the planets!

400 of these bodies are known to Science!
UNDERSTANDING THE STRUCTURE OF COMETS!

The Four Parts of a Comet!

Nucleus
Coma
Hydrogen Envelope
Tails (Dust, Ion, Sodium, etc.)
UNDERSTANDING THE STRUCTURE OF COMETS!

*Morphology is the Key!*

As a comet approaches or recedes from the Sun within the planetary domain of the solar system the solar pressure and energy from the Solar Wind & its radiation pressure react with the comet nucleus. This in turn will form a variety of structures to the comet that give it its' distinctive structure thru the processes of sublimation, evaporation, ionization, pressure outflow, etc.
UNDERSTANDING THE STRUCTURE OF COMETS!

Morphology is the Key!

<table>
<thead>
<tr>
<th>Structural Component</th>
<th>Definition of Component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nucleus</strong></td>
<td>Comets are essentially ‘dirty snowballs’ or asteroids covered in and containing internal cavities (reservoirs) of frozen volatiles (ex.: H2O, frozen Oxygen, Carbon compounds, etc.) and originate from outside the solar system from the Kuiper Belt (short to medium period comets) to the Oort Cloud (up to extremely long period comets). The details in composition and overall structure internal and external vary considerably and they range in size from 100m to 40 km across! As of June 2013 there are about 4300 known so far, but they may number in the trillions!</td>
</tr>
<tr>
<td><strong>False Nucleus</strong></td>
<td>The central brightening of the coma showing the position of the nucleus, but only the extremely ‘high pressured’ jets are visible containing the escaping volatiles from such internal cavities breaking thru to the surface of the nucleus (the actual nucleus is not visible in most telescopes).</td>
</tr>
<tr>
<td><strong>Coma</strong></td>
<td>The trace atmosphere of dust particles, icy crystals, evaporated or sublimated molecules, ions, etc.) that surround the nucleus before being pushed away by the radiation pressure and solar wind producing the comet’s tails. The re are two sub components (inner and outer comas) differing only by concentration of materials emanating from the nucleus. The most common compounds C2 &amp; C3 (carbon compounds) along with (CN-) cyanogen compounds make the nucleus appear greenish or some combination of blue and green to the human eye.</td>
</tr>
<tr>
<td><strong>Ion Tail (Type I)</strong></td>
<td>The volatiles that can come from the nucleus are ionized by solar Ultraviolet radiation (UV photons) and the magnetic field of the Sun will drive the particles in a tail away from the Sun (Anti – Solar) direction at speeds up to 500 km/s. The most common ions (CO+) carbon monoxide appears blue to the human eye.</td>
</tr>
<tr>
<td><strong>Dust Tail (Type II)</strong></td>
<td>Nanoscopic to tiny mesoscopic (up to millimeter sized) dust particles that pushed away from the Coma via pressure from the Solar radiation within the solar wind and can very diffuse structurally and only rerdiate back long wavelength or low energy light (appearing white, yellowish, or soft – pink). The particles will spread in individual orbits around the Sun kept away from the Sun’s gravity due to its’ radiation pressure giving the tail its’ curved shape. Dust Tails can extend up to 100 million km (62.1 million mi) from the Nucleus and Coma!</td>
</tr>
<tr>
<td><strong>Sodium Trail (Type III)</strong></td>
<td>Visible only in very, large telescopes there tails are composed of neutral atoms of Sodium striking out from the coma and not the nucleus possibly from either collisions between dust particles, UV solar erosion of the dust particles, or some unknown mechanism all occurring within the coma. Sodium tails can reach up to 50 million km away from the Sun along a similar path to the ion tail!</td>
</tr>
<tr>
<td><strong>Dust trail (Anti – Tail)</strong></td>
<td>Larger dust particles that have enough mass to be more attracted to the Sun’s gravity and are less likely to be influenced by the Sun’s radiation pressure and are geometrically opposite to the Types I &amp; II tails. They will form a dust disk along the orbital path of the comet that only visible from Earth as a spike heading towards the Sun, but only visible when the comet crosses the orbital plane of the Earth!</td>
</tr>
<tr>
<td><strong>Cometary Bow Shock</strong></td>
<td>Once the solar wind interacts with a comet plunging thru the solar wind a bow shock forms around the outer coma much the same way the magnetic field of a planet forms a bow shock. The solar wind forms a Hydrogen envelope just outside the frontal boundary of the outer coma creating a plasma layer of hydrogen ions that release Lyman – alpha radiation as a byproduct!</td>
</tr>
</tbody>
</table>
It is okay if you don’t entirely understand what is going on here:

The only important fact are the particles within the solar wind and the comet plunging thru it will force a massive buildup of particles between the bow shock and the cometopause (the boundary of the comet’s induced magnetic field) forming the outer boundary of influence for the outer coma! This thick bow shock that contains the Hydrogen plasma is also known as the cometosheath and works similar to that of planet’s magnetosheath where the influence of the magnetic field is weaken and the behavior of the Sun’s magnetic field propagating (moving) thru the solar wind begins to dominate going from the comet or planet outwards towards the solar wind! Figure 2.2 compared to Figure 2.1 shows similarities in the Earth’s magnetic field to the behavior of the Coma and induced magnetic field of the Comet as a result of interaction with the charged particles and radiation of the solar wind!
UNDERSTANDING THE STRUCTURE OF COMETS!

Basic Facts about a Comet’s Nucleus:

I) All Comets Are Dirty Snowballs or Icy Dirtballs
II) A composition of Rock, Dust, and Icy Volatiles
III) Complex and exotic organics known only on Earth have been confirmed to exist on one comet!
IV) The Volatiles are effected by the Solar Radiation and sublimate
V) The sublimated Gas form an atmosphere around the Nucleus (Coma)
VI) Average Albedo is 0.04 for the Nucleus (blacker than Coal!)
VII) Estimated Average Density: 0.6 g/cm³ (60% of that of H₂O)
VIII) Most Nucleus range between 1 – 10 km in size
IX) Extreme Range: (SOHO) P/2007 R3 - 100 to 200 meters & (Hale Bopp) C/1997 OH1 = 60 km!
UNDERSTANDING THE STRUCTURE OF COMETS!

The structure of a comet’s nucleus has varying degrees of fragility depending on the distribution, size, and composition of the icy volatiles distributed on the surface and the interior reservoirs within the nucleus.

Comets that do survive many journeys around the Sun until their supply of volatiles is thoroughly exhausted can be reclassified as either C or S - group (stony) asteroids. A small concentration of heavier metals do exist in some nuclei based on spectral analysis. All cometary nuclei that have been studied by ground observations, orbiting observatories, and planetary spacecraft show pristine surfaces of simple chemistry with a lack of cratering.

The solar radiation propagates through the nucleus exerting pressure on the interior reservoirs and the volatiles sublimate into gases that exert pressure out to the nucleus surface as gas jets along with some of the dust coating the surface. This immediately forms a localized condensate that becomes the source material for the coma and tails!
THE TECHNIQUES OF OBSERVING COMETS!

Degree of Condensation (DC)

<table>
<thead>
<tr>
<th>DC value</th>
<th>Definition to numerical DC designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Diffuse coma of uniform brightness</td>
</tr>
<tr>
<td>1</td>
<td>Diffuse coma with slight brightening towards center</td>
</tr>
<tr>
<td>2</td>
<td>Diffuse coma with definite brightening towards center</td>
</tr>
<tr>
<td>3</td>
<td>Centre of coma much brighter than edges, though still diffuse</td>
</tr>
<tr>
<td>4</td>
<td>Diffuse condensation at centre of coma</td>
</tr>
<tr>
<td>5</td>
<td>Condensation appears as a diffuse spot at centre of coma – described as moderately condensed</td>
</tr>
<tr>
<td>6</td>
<td>Condensation appears as a bright diffuse spot at centre of coma</td>
</tr>
<tr>
<td>7</td>
<td>Condensation appears like a star that cannot be focused – described as strongly condensed</td>
</tr>
<tr>
<td>8</td>
<td>Coma virtually invisible</td>
</tr>
<tr>
<td>9</td>
<td>Stellar or disk like in appearance</td>
</tr>
</tbody>
</table>

All observations of comets are broken down into three factors:

1) Estimating magnitudes for light curves to predict future brightness, coma observations, and observations that concern with a comet’s tail(s).

2) For the coma or a comet’s head there are two characteristic features that are important for study:
   - Degree of condensation (DC)
   - Coma size measured in arcminutes.

3) The classification system for determining the DC is based on a positive integer system from 0 to 9 as shown below.
THE TECHNIQUES OF OBSERVING COMETS!

Degree of Condensation (DC)

The chart displayed shows a visual comparison to determining the degree of condensation for a comet’s coma!

Note the two extra designations:

2S: A Sharp, distinct stellar center with an extremely dissipated outer coma barely visible from the night background.

3D: The central condensate disperses with an extremely faint outer coma very little contrast from the background. The condensate is sharply distinguishable from the outer coma.

The chart is courtesy of the Isle of Man Astronomy Club.

http://www.iomastronomy.org/sections/comets/comet.html

6 March 2015
THE TECHNIQUES OF OBSERVING COMETS!

Catching the Comet:

1. Observations of the Coma are the easiest.
2. Most comets do not produce distinctly visible tails for the naked eye! (binos or telescope)
3. Judgements on the visual magnitude can vary substantially based on biased human observations and photometry measurements in a single night!
4. The Dust tail is the easiest to observe; the ion tail is difficult unless extreme activity (Outbursts – either continuous, single or multiple events).
5. There can be more than one dust tail and the ion plus dust tail is very pronounced in comets with small coma, but large comas are very distinct over tails! (Maybe!)
THE TECHNIQUES OF OBSERVING COMETS!

Do Not Assume you are observing the ‘Anti – Tail’!

Foreshortening Effect!

The appearance of the comet’s tail due to the geometric orientation between the Earth and a Comet.

(100% means the comet’s tail is parallel with the face of the Earth where as 0% means the tail is exactly perpendicular with respect to the face of the Earth!)
THE TECHNIQUES OF OBSERVING COMETS!

Foreshortening Effect!

The appearance of the comet’s tail due to the geometric orientation between the Earth and a Comet.

(100% means the comet’s tail is parallel with the face of the Earth where as 0% means the tail is exactly perpendicular with respect to the face of the Earth!)

a) 100%
b) 60%
c) 30%
d) 5 – 10 %
THE TECHNIQUES OF OBSERVING COMETS!

How to measure visual magnitude?

Sidgwick's or In – Out method – An observer memorizes the brightness of the stars around a comet in a particular star field with the angular size of the in-focus comet. Rack out the telescope in order for the coma to have the same diameter as the surrounding stars. Several observations are required to reach a definite brightness value and it works well for diffuse comets!

Bobrovnikoff’s or Out – Out method – Simultaneously defocus the comet with the comparison stars for side by side, direct comparison. It works best for very bright comets providing a very steep brightness gradient for determining visual magnitude! Works well for highly condensed comets!

Beyer’s method – The comet’s coma is defocused in conjunction with the stars until all objects are out of focus with the background of space. Incremental refocusing will determine the brightness of comet with respect to the surrounding stars! Works well for very condensed comets with a more stellar – like appearance, but smaller angular diameter.
THE TECHNIQUES OF OBSERVING COMETS!

How to measure visual magnitude?

**Morris’s or modified Out method** – Formulated by Charles Morris & Stephen James O’Meara. Bridges the gap between the Sidgwick & Bobrovnikoff methods for moderately condensed comets.

The comet is placed out of focus to flatten the brightness profile. It is easier to determine the average surface brightness along with the out of focus angular diameter. Take the comparison stars and place them out of focus for determining a more precise visual magnitude value. More difficult to master than all other techniques.

**The In – Focus Method** – A Centuries old technique in visual comparing the brightness of a comet with the neighboring stars with everything in focus. Works well for compact, stellar-like comets to prevent any underestimation of visual brightness. Can work well with other methods to determine more accurate values for the visual magnitude of historical comets before the 20th century!
THE TECHNIQUES OF PREDICTING COMETS!

How to plot a comet across the sky? Orbital Elements

e: eccentricity – elliptical shape of an orbit!
1. e = 0 it is circular
2. 0.01 to 0.99 from slightly oval to extremely oval
3. e = 1 it is a parabolic path
4. e > 1 it is a hyperbolic path

a: semi – major axis (measured in AU)

q: perihelion distance (measured in AU)
i: orbital inclination
(The tilt to the plane of the ecliptic – plane of the Earth’s orbit measured in degrees!)

node: longitude of the ascending node
peri: the argument of perihelion
M: mean anomaly
tp: time of perihelion passage
period: orbital period (measured in years)
n: mean motion (measured in degrees/day)
Q: aphelion distance (measured in AU)
THE TECHNIQUES OF PREDICTING COMETS!

How to plot a comet across the sky? Orbital Elements

e: eccentricity – elliptical shape of an orbit!
   1. e = 0 it is circular
   2. 0.01 to 0.99 from slightly oval to extremely oval
   3. e = 1 it is a parabolic path
   4. e > 1 it is a hyperbolic path

a: semi – major axis (measured in AUs)
   *Not to be confused with perihelion, aphelion, apogee, or perigee!

q: perihelion distance (measured in AUs)
i: orbital inclination
   *(The tilt to the plane of the ecliptic – plane of the Earth’s orbit measured in degrees!)*

node: longitude of the ascending node
peri: the argument of perihelion
M: mean anomaly
tp: time of perihelion passage
period: orbital period (measured in years)
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Q: aphelion distance (measured in AUs)
THE TECHNIQUES OF PREDICTING COMETS!

How to plot a comet across the sky? Orbital Elements

Comet: 45P/Honda – Mrkos - Pajdusakova

NASA/JPL Small Body Database Browser
### Ephemeris Term

<table>
<thead>
<tr>
<th>Ephemeris Term</th>
<th>Definition (plus additional comments)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date</strong></td>
<td>Month and Year using the standard Gregorian calendar.</td>
</tr>
<tr>
<td><strong>UT or TT</strong></td>
<td>Right Ascension based on the Epoch J2000 (longitudinal coordinate for the celestial sky) measured in hours, minutes, and seconds.</td>
</tr>
<tr>
<td><strong>Dec (2000)</strong></td>
<td>The solar distance measured in AU's (the distance between the comet or comet–like body and the Sun).</td>
</tr>
<tr>
<td><strong>Delta</strong></td>
<td>The distance from Earth measured in AU's (1 AU = 1 Astronomical Unit = 92 955 807 mi = 149 597 871 km as the mean distance between the Earth and Sun).</td>
</tr>
<tr>
<td><strong>R</strong></td>
<td>Solar elongation which is the angle of separation between the observed object and the Sun as measured across the night sky as measured in degrees.</td>
</tr>
<tr>
<td><strong>Phase (Ph.)</strong></td>
<td>Phase angle between the Sun, the celestial object, and the observer on the surface of the Earth. Also known as the Sun–Object–Observer angle.</td>
</tr>
<tr>
<td><strong>M1</strong></td>
<td>M1: The visual magnitude of the celestial object as observed on the surface of the Earth at sea level. (Note M1 values predicted by the Minor Planet Center can differ from actual visual reports obtain in the field!)</td>
</tr>
<tr>
<td><strong>Mpred</strong></td>
<td>The predicted absolute magnitude which is calculated from a series of initial observations upon the discovery or recapture of a periodic comet which can change if the comet gets brighter or fainter as the internal conditions of the comet's nucleus changes during it's close approach around the Sun!</td>
</tr>
<tr>
<td><strong>M2</strong></td>
<td>The nuclear magnitude of the Comet which is also the visual magnitude of the false nucleus. (Rarely shown on a Comet's ephemeris data spreadsheet unless all values show a visual brightness value above 19th magnitude!)</td>
</tr>
<tr>
<td>*<strong>/min</strong></td>
<td>The progression or motion across the sky as measured in arcseconds per minute.</td>
</tr>
<tr>
<td><strong>P.A.</strong></td>
<td>Position angle while undergoing motion in the celestial sky. (P.A. is the same method applied to binary stars with starts at N goes counterclockwise in an easterly direction!)</td>
</tr>
<tr>
<td><strong>Moon Phase</strong></td>
<td>A Numerical value for designating the phases of the Moon on a scale of (0.00 – 1.00): A New Moon = 0.00, Waxing or Waning Crescent = (0.01 – 0.49), Half Moon (1st or Last Quarter = 0.50), Waxing or Waning Gibbous = (0.50 – 0.99), &amp; Full Moon = 1.00.</td>
</tr>
<tr>
<td><strong>Foreshortening (% Fore.)</strong></td>
<td>The appearance of the comet's tail due to the geometric orientation between the Earth and a Comet. (100% means the comet's tail is parallel with the face of the Earth where as 0% means the tail is exactly perpendicular with respect to the face of the Earth!)</td>
</tr>
<tr>
<td><strong>Altitude (Alt.)</strong></td>
<td>Altitude is the angle of position for any celestial object visible in the night sky regardless of cardinal direction. The angle has a range of only (0° to 90°) although (0° to -90°) can be applied to objects not visible. The altitude position will change throughout the sidereal day.</td>
</tr>
<tr>
<td><strong>Azimuth (Azi.)</strong></td>
<td>Azimuth is the establish angle of position for any celestial object visible in the night sky. The range starts at the North (0°) heading clockwise eastward with the following cardinal positions: NNE (22.5°), NE (45°), ENE (67.5°), E (90°), ESE (112.5°), SE (135°), SSE (157.5°), S (180°), SSW (202.5°), SW (225°), WSW (247.5°), W (270°), WNW (292.5°), NW (315°), &amp; NNW (337.5°).</td>
</tr>
</tbody>
</table>
THE TECHNIQUES OF PREDICTING COMETS!

How to plot a comet across the sky? Spreadsheet of Ephemeris Data (UTC 06hrs – CST Midnight or 00hrs)

Perturbed ephemeris below is based on elements from MPEC 2017-C71.

This is Data Output from the IAU Minor Planet Center (Minor Planet & Comet Ephemeris Service)

George Observatory Code 735 – Sometimes the comet is not observable!
THE TECHNIQUES OF PREDICTING COMETS!

How to plot a comet across the sky?

A Good Sky Chart plotting the elements and a photometry profile for when it is the best range of dates to observe at maximum brightness or to chart the changes in brightness!
THE TECHNIQUES OF PREDICTING COMETS!

How to plot a comet across the sky?

Comet: 45P/Honda – Mrkos – Pajdusakova
Perihelion: 31 December 2016 (0.533 AU – 79,736,800 km or 49,516,553 mi)
Perigee: 11 February 2017 (0.083 AU – 12,416,800 km or 7,710,833 mi)

THE TECHNIQUES OF ANALYZING COMETS!

Many of the features to a comet can be plotted based on visual reports and photographic observations as indicated by the 'blue – colored' crosshairs in both of the charts above! Among the physical features that can be plotted as parameters that are distinct in the analysis of comets for predicting future behavior are the following: Light Curve, Tail Length, DC and Size of Coma, and the position angle for a comet!

Based on the plots above Comet 45P the visual reports are fitting with the predicted light curve and the reports of the tail length vary widely from 5 – 240 arcminutes. Note the gradual decrease in the reported tail length as the comet is now further past perihelion!

THE TECHNIQUES OF OBSERVING & ANALYZING COMETS!

Coma DC plot for Comet 45P/Honda-Mrkos-Pajdusakova

Coma diameter plot of Comet 45P/Honda-Mrkos-Pajdusakova

Be aware that the horizontal axis for these plots in spite of being designated as ‘Date 2016’ the dates above are plotted from 5 Dec 2016 through 20 Feb 2017! Based on the plots above Comet 45P before perihelion passage appeared to show a wide change in its coma structure with reports indicating DC values from 3 – 7 and 1 – 3.5 after perihelion passage while the Coma diameter appears to show a smaller diameter between 0.5 – 8 arcminutes before perihelion and sizes between 4 – 60 arcminutes after perihelion. These variations are likely due to human interpretation of visual observation and photographic analysis and the orientation of the comet in its orbit around the Sun with respect to the Earth’s position in its orbit about the Sun! Maximum Coma Diameter of 60 minutes fits perfectly with 45P at perigee on 11 February 2017!

THE TECHNIQUES OF OBSERVING & ANALYZING COMETS!

Comet 45P like any comet in which a tail is report can look towards the orientation of its tail with respect to the direction of the North Celestial Pole much the same way that the 'Position Angle' is applied to stellar binaries. Based on the few field reports plotted above the comet’s P.A. (Position Angle) was fixed at a very, narrow range between 70° – 90° degrees indicated that with respect to the North Celestial Pole (NCP) the tale. The interpretation being that the tale was oriented in a eastward to east northeastward while travelling through the skies of the constellation of Capricornus prior to the time of perihelion passage!

In the time around and after perigee the P.A. changes to a range 250° – 325 degrees indicating a shift in the tails position from west southwestward just before and around perigee to being northwestward in the weeks after perigee while 45P continues to progress across the constellations of the Spring night sky!

The techniques of observing & analyzing comets!

**Comet: 45P/Honda – Mrkos – Pajdusakova**

**Visual Magnitude Projections & Predictions**

\[ m_1 = 14.2 + 5 \log d + 23.0 \log r \] (2016 Dec. 31)

\[ m_1 = 12.0 + 5 \log d + 15.0 \log r \] (2016 Dec. 31 -)

\[ \Delta(d) \] is the left column & \( r \) is the right column

<table>
<thead>
<tr>
<th>Date</th>
<th>Delta</th>
<th>r</th>
<th>M1</th>
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<td>12/24/16</td>
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</table>

**Perihelion: Date – 12/31/2016**

**Visual Mag. Predicted: 7.2**

**Perigee: Date – 2/11/2017**

**Visual Mag. Predicted: 6.46**

**Predicted Brightness Max. may differ from either date!**

(Visual Mag. 6.39 on 9 – 10 Feb 2017)
THE TECHNIQUES OF OBSERVING & ANALYZING COMETS!

Actual Observations

Around the time of Perihelion

Visual Report (Brightest Results)

Mv: 6.6 on 12/31/2016 @ 17:04 UTC
Yukihiro Sugiyama, Japan

CCD Report (Brightest Results)
Mv: 6.7 on 01/02/2017 @ 14:88 UTC
Artyom Novichonok, Kislovodsk, Russia
Software Use: Astrometrica 4.9
Star Catalogue: Tycho 2 Catalogue
CCD Imager with 0.4m f/5 refractor
Estimated Size of Coma: 4 arcminutes
Estimated DC: 4

Around the time of Perigee

Visual Report (Brightest Results)
Mv: 6.7 on 2/11/2017 @ 12:48 UTC
Salvador Aguirre, Hermosillo, Sonora, Mexico

CCD Report (Brightest Results)
Mv: 5.9 on 02/10/2017 @ 12:00 UTC
Thomas Lehmann, Weimar, Germany
Star Catalogue: Tycho 2 Catalogue
CCD Imager with 10.2 cm f/5 refractor
Estimated Size of Coma: 60 arcminutes

Comet: 45P/Honda – Mrkos – Pajdusakova

Visual Magnitude Projections & Predictions

m1 = 14.2 + 5 log d + 23.0 log r [0, ] (2016 Dec. 31)
m1 = 12.0 + 5 log d + 15.0 log r [0, ] (2016 Dec. 31 - )

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</table>

Perihelion: Date – 12/31/2016
Visual Mag. Predicted: 7.2

Perigee: Date – 2/11/2017
Visual Mag. Predicted: 6.46

Predicted Brightness Max.
may differ from either date!
(Visual Mag. 6.39 on 9 – 10 Feb 2017)
Here are two images of comet 45P taken over a period of 7 months 18 days where the reported brightness continues to fade by time of night when the comet will rise and the changes in visual magnitude for the comet. Notice the left image shows 45P with a distinct condensed, greenish coma and a long dust tail with no foreshortening effect. The right image was taken in the early morning hours before sunrise with a fading coma against the twilight and not so visible tail.
Note the drawings by amateur astronomer Michael Deconinck. Each images has a ‘field of view’ equal to 60’ or 60 arcminutes (about two, average full Moon widths) across. The two images have a time separation of 10 days with the coma on the left lacking both an inner brightness nor is there any indication of a false nucleus. The DC for the coma in the left image is equal to a value of 1 while in the right image the DC values increases to about 2 or 3 depending on how you classify the centralization of brightness from the rest of the coma. Also notice that the tail is now visible in this image with the tail length being less than 1 arcminute in length.
Here is the difference with 45P in the middle of February 2017 with the outer coma extending outwards with a greatly extended, inner coma both showing a bow shock effect as the comet plunges through the inner solar system at a top speed of 55.113 km/s (34.225 mi/s) at perihelion on 31 December 2016. The comet in this sketch was made during the time of perigee passage at a velocity 36.851 km/s (22.884 mi/s). The passage across the sky at the time of this sketch peaked at 22.68°/min around 11 February at its closest approach to Earth!

Foreshortening values for the Tail of 45P:

1 Jan 2017 – 4%
15 Jan 2017 – 43%
27 Jan 2017 – 79% (Maximum Effect)
1 Feb 2017 – 65%
15 Apr 2017 – 57%
1 June 2017 – 57%
11 - 12 Feb 2017 - 0% (No Tail Visible)
1 Mar 2017 – 72%
4 – 7 Mar 2017 – 75%
1 Apr 2017 – 61%
(22 April to 23 May) 2017 – 55%
LETS GO PICK SOME COMETS!

41P/Tuttle – Giacobini – Kresak
24 February 2017
Roland Fichtl

Discoverers: Horace Parnell Tuttle
Michel Giacobini
Ľubor Kresák

Discovery Date (Original) : 3 May 1858 (Tuttle)
Rediscovery Dates: 1 June 1907 (Giacobini)
24 April 1951 (Kresák)

Instruments: 15 inch refractor (1858)
(Great Harvard Observatory, Cambridge, Massachusetts, USA)
30 inch refractor (1907)
(Nice Observatory, Mont Gros, Nice, France)
60 cm Zeiss Parabolic reflector w/ Maksutov Camera (1951)
(Skalnaté Pleso Observatory, Modern Day Slovakia, EU)

Epoch (Time – based reference point): 6 March 2006
Aphelion: 5.122 AU
Perihelion: 1.048 AU
Semi – Major Axis: 3.085 AU
Eccentricity: 0.6604 (Very Elliptical Orbit)
Orbital Inclination: 9.2294° or (9° 13’ 45.84”)
Minimum Orbital Intersection Distance (MOID)
• Perigee – 0.13 AU
• Perijove (closest distance to Jupiter) – 0.48 AU
Next Perihelion Date: 12 April 2017
LETS GO PICK SOME COMETS!

**Visual Magnitude Projections & Predictions**

\[ m_1 = 13.5 + 5 \log d + 18.0 \log r \]

\[ m_1 = 8.5 + 5 \log d + 55.0 \log r \]

\[ m_1 = 9.0 + 5 \log d + 30.0 \log r \]

Time of Perigee Passage: 0.142 AU on (30 March – 3 April) 2017

(21,242,897.6 km or 13,199,684.8 mi)

Time of Perihelion Passage: 1.045 AU on (11 – 14) April 2017

(156,329,774.9 km or 97,138,525.6 mi)

Predicted Brightest Visual Mag.: 6.6 on (4 – 11) April 2017

*Note that the square brackets above indicate the days (-) before perihelion and (+) after perihelion. Day 0 is the central date of perihelion passage!
Note that the most important component to any comet is its coma. It is the most distinguishing physical property for any comet being the first and last parameter to be observed, photographed, studied, and analyzed! The two important characteristics of any coma is the DC and Coma diameter (although it is measured in arcminutes).

DC for Comet 41P has been reported from wide range of values (1 – 5.5) with the most of visual reports giving the coma a DC of 3 which indicates a bright outer coma with a faint, but distinct inner coma. The coma diameter field reports are in two distinct categories with larger diameter range of 10 – 45 arcminutes and a smaller diameter range of 0.25 – 15 arcminutes). The majority of field reports in the statistical distribution of the data places the coma diameter in the smaller range of size.

LET'S GO PICK A COMET!

Brightness Projections

\[ m_1 = 13.5 + 5 \log d + 18.0 \log r \quad (-65) \quad (2017 \text{ Feb. 7}) \]
\[ m_1 = 8.5 + 5 \log d + 55 \log r \quad [-65, 0] \quad (2017 \text{ Feb. 7} - 2017 \text{ Apr. 13}) \]
\[ m_1 = 9.0 + 5 \log d + 30 \log r \quad [0, ] \quad (2017 \text{ Apr. 13} - ) \]

Progression Rate Across the Sky!

<table>
<thead>
<tr>
<th>P.A.</th>
<th>°/min</th>
<th>P.A.</th>
<th>°/min</th>
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<tbody>
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<td>April 9</td>
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<td>April 2</td>
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<td>4.75 – 5.20</td>
<td>April 10</td>
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<tr>
<td>April 3</td>
<td>086.8 – 094.1</td>
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<td>April 4</td>
<td>091.4 – 098.8</td>
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<td>April 5</td>
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<td>April 6</td>
<td>100.4 – 107.6</td>
<td>4.58 – 5.00</td>
<td>April 14</td>
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</table>

41P will be a circumpolar comet during the months of March and April as it crosses the constellation flanking Ursa Major. The comet will reach a maximum position of declination: 64° 59' 51" on 3 April 2017 from 06:59 – 07:25 UTC (00:59 – 01:25 CDT)!
LETS GO PICK A COMET!

Time of Perihelion Passage: 12 Apr 2017 @ 05:59:24.8 UTC
Perihelion Distance: 1.045 AU (156,332,000 km or 97,082,172 mi)

Time of Perigee Passage: 30 March – 3 April 2017
Perigee Distance: 0.142 AU (21,243,200 km or 13,192,027 mi)

Aphelion Distance: 5.123 AU – Jupiter Comet!!!
CNebulaX Project: Path of Comet 41P: (8 Jan – 7 Jul) 2017

Constellations

- Cancer (SE Region: 8 – 17 Jan)
- Leo (W Region: 18 Jan – 5 Mar)
- Leo Minor (W Region: 6 – 13 Mar)
- Ursa Major (Central Region: 14 Mar – 1 Apr)
- Draco (E to Central Region: 2 – 26 Apr)
- Hercules (E Region: 27 Apr – 3 June)
LETS GO PICK A COMET!

The table on the left shows the ephemeris for 41P/Tuttle – Giacobini – Kresák.

The range of dates: 1 March through 1 May

Note that the comet is best observed when there is minimal moon and best on the table of Moon Phases.

Location: HMNS George Observatory, Brazos Bend State Park, Texas, USA

March 1: 0.09 (Near New Moon)  
March 5: 0.47 (1st Qtr. Moon)  
March 12 – 13: 1.00 (Full Moon)  
March 20: 0.54 (Last Qtr. Moon)  
March 28: 0.00 (New Moon)  
*April 4: 0.55 (1st Qtr. Moon)  
*April 10: 1.00 (Full Moon)  
*April 19: 0.52 (Last Qtr. Moon)  
April 26: 0.00 (New Moon)  
May 3: 0.52 (1st Qtr. Moon)  
May 10 – 11: 1.00 (Full Moon)  
May 19: 0.48 (Last Qtr. Moon)  
May 26: 0.00 (New Moon)  
June 1: 0.47 (1st Qtr. Moon)  

*Note that the conditions for observing 41P are not very favorable since the time from April 4 – 19 during the two weeks after perigee when the comet is expected to be at its brightest between perigee and perihelion and the time of perihelion passage. This is in spite of the fact that comet 41P will be a circumpolar comet!

<table>
<thead>
<tr>
<th>Date</th>
<th>Perihelion (1 March)</th>
<th>Passage</th>
<th>Distance (AU)</th>
<th>Brightness (mag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1:</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 5:</td>
<td>0.47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 12–13</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 20:</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 28:</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* April 4: 0.55 (1st Qtr. Moon)  
* April 10: 1.00 (Full Moon)  
* April 19: 0.52 (Last Qtr. Moon)  

Note that the conditions for observing 41P are not very favorable since the time from April 4 – 19 during the two weeks after perigee when the comet is expected to be at its brightest between perigee and perihelion and the time of perihelion passage. This is in spite of the fact that comet 41P will be a circumpolar comet!
LETS GO PICK SOME COMETS!

**Discoverer:** A. Jess Johnson

**Discovery Date (Original):** 3 November 2015

**Instruments:** 0.68 m (27 in) Schmidt – Cassegrain Reflector  
(Catalina Sky Survey, Mt. Lemmon IR Observatory, Stewart Observatory, Univ. of Az., NASA, Arizona, USA)

**Epoch (Time–based reference point):** 10 February 2016  
**Aphelion:** Not Applicable  
**Perihelion:** 1.63714 AU  
**Visual Magnitude (On Date of Discovery):** 17.1  
**Semi–Major Axis:** (Incoming Orbit – 59,200 AU or ~8.856 trillion km)  
**Eccentricity:** 1.0009 (Hyperbolic path)  
**Orbital Inclination:** 48.87499° or (48° 52' 30'')  
**Orbital Period:** (Incoming pathway – 14.4 million years)  
**Next Perihelion Date:** 12 June 2017

Comet C/2012 V2 has the ‘C’ designation assigned to comets that do not have long term stable orbits and in many cases can be predominantly ‘non–periodic’ comets. Some of these comets can either have a parabolic path (return to the outer regions) or hyperbolic (reach escape velocity from the Solar System entirely)! It is not unknown for ‘C’ designation comets to eventually return to the inner solar system in a new semi–orbital or non–orbital trajectory, but for periods lasting upwards of tens of millions of years. These comets likely reside from the Oort Cloud at the very primeval edges of the solar system at the edge of the Sun’s gravitational influence.
LETS GO PICK SOME COMETS!

The left image shows the path of C/2015 V2 from 1 July 2015 in the constellation of Lynx undergoing retrograde motion from 29 October 2015 to 28 June 2016 in the region between Lynx & Ursa Major. The comet then progressed eastwards across Ursa Major during the period: (8 July – 28 October) 2016. Then the comet moves through Canes Venatici, then Boötes (both northern regions) from 29 October 2016 to 20 February 2017. Currently Comet Johnson is undergoing a tighter retrograde loop in the NW region of Hercules near the star ‘Rukbalgethi Shemali’ or ‘the northern knee’ (Tau Herculi) during the period of (20 February – 24 April) 2017. C/2015 V2 will then head SE to southwards from (25 April crossing into Boötes on 3 May) as crosses into the north boundary of Virgo on midnight, 14 June. The comet will pass into the constellation of Lupus by late August and will be lost to observers in the northern hemisphere by the civil and nautical twilight after sunset before 1 September. The right image shows the comet moving deeper into the southern celestial skies with a maximum southern declination of 57° 04' 2.1" S (J2000 Epoch) on 19 November 2017 during the period of (14:50 – 16:44) UTC.
LETS GO PICK SOME COMETS!

Progression of the visual and measured brightness of C/2015 V2 showing a gradual brightening of the comet from 16.4 (15 Jan 2016) to a peak brightness between visual magnitudes of 5 – 6 by the time of perihelion passage on 12 June 2017! Currently the last reported visual magnitude based on the left graph is 9.5 on 2 March with average varying around 10.6 – 10.7! The right graph shows a photometry or light curve projection with the comet passing 12th magnitude brightness by 1 January 2018. Note the slight oscillating or wave pattern predicted for the brightness and from the measured values on either side of the perihelion passage. This is characteristic of the comet’s slight fluctuation in its ever increasing Solar and Earth distances and this is mostly due to the 365.26 day period for the sidereal year as the orbital period of the Earth about the Sun!
LETS GO PICK SOME COMETS!

The DC for Comet Johnson for the period of (late February to Early August) 2016 was in a tight range of 7 – 8. All later observation reports show a greater range of DC values from 1 to 8 from Oct 2016 thru January 2017 and becoming a tighter from 2 – 6 since the end of January 2017. This indicates that the comet is attempting to produce a bright, distinguishing outer coma with a sharper defined inner coma prior to perihelion. Notice on the right plot for Coma diameter as the size range for all of 2016 was very tight; <0.1 to 2 arcminutes. Since the star of December 2016 two noticeable pathways in the change of the coma size from all recorded field reports. A rapid increase in size from 2 to 20 arcminutes stabilizing at 16 and a more gradual and semi-stable condition of 1 – 4.5 arcminutes in the early quarter of this year!
The tail length for Comet Johnson based on all previous field reports (visual and CCD imaging) shows a very narrow tail <10 arcminutes in length and (be aware that the angular diameter of the average full moon is 31 arcminutes). However, the PA angle has the tail oriented between 300 – 330 degrees and this indicates that the tail is positioned to the NW to NNW from the coma upon the comet approaching perihelion passage.
LETS GO PICK A COMET!

Brightness Projections

\[ m_1 = 13.5 + 5 \log d + 18.0 \log r \quad (-65, 2017 Feb. 7) \]

\[ m_1 = 8.5 + 5 \log d + 55 \log r \quad (-65, 2017 Feb. 7 - 2017 Apr. 13) \]

\[ m_1 = 9.0 + 5 \log d + 30 \log r \quad (2017 Apr. 13 - ) \]

Time of Perihelion Passage: 10 – 16 June 2017
Date of Minimum Perihelion: 12 June 2017 @ 09:08:42.6 UTC
Perihelion Distance: 1.637 AU (244,891,714.3 km or 152,168,197.5 mi)

Time of Perigee Passage: 4 – 6 June 2017
Date of Minimum Perigee: 5 June 2017 from (00:56 – 04:31) UTC
Perigee Distance: 0.811 AU (121,331,000 km or 75,391,360.7 mi)
LETS GO PICK SOME COMETS!

The 'light blue' segment of the comet's path places it currently above the plane of the ecliptic where the rest of the hyperbolic path is in the 'dark blue' tone which places the comet on future dates below the ecliptic plane. The ecliptic plane corresponds to the plane of the Solar system being the plane of the Earth's solar orbit! The comet will be crossing the ecliptic plane on 30 June 2017 long after it has reached its predicted brightest, visual magnitude, time of perigee and perihelion passages.

The ephemeris table to the right shows the essential coordinates for determining the path of characteristics of the comet for the period: (1 May to 1 July) 2017!

Earth Distance: 1.596 AU
Sun Distance: 2.055 AU

Mar 10, 2017

Earth Distance: 1.596 AU
Sun Distance: 2.055 AU
Comet C/2015 V2 has for most of 2016 remained the general region of the northern circumpolar constellations. Since early July 2016 the comet was progressed in pure eastward direction through the central region of Ursa Major south of the ‘Big Dipper’ asterism up until late October 2016. Then Comet Johnson continued through the northern region of Canes Venatici from Late October 2016 through Late December 2016. Then it continued to progress eastward across the narrow northern region of Boötes from 20 December 2016 to 9 February 2017. Currently the comet is in a narrow retrograde motion as shown in the loop at the center of the image in the northwestern region of Hercules from 19 February to 25 April 2017. The comet will afterwards return to the constellation of Boötes travelling SE to southward along its eastern to south central regions from 3 May to 14 June. Then continues it’s southward path through the eastern regions of Virgo thru mid July!
LETS GO PICK SOME COMETS!

The Retrograde Path of C/2015 V2 (Johnson)

Comet C/2015 V2 in its current retrograde motion from 19 February to 25 April 2017 in the northwest region of the constellation of Hercules! The retrograde motion during this period is decreasing from 0.65"/min to a minimum of 0.093"/min or 93 milliarcseconds/min at the eastern end of the loop before increasing again to 0.99"/min on 25 April 2017 at the crosshairs of the loop!
LETS GO PICK SOME COMETS!

The Projected Path of C/2015 V2 (Johnson)
During the time of both perihelion and perigee passage!

2017 Foreshortening values for the Tail of C/2015 V2

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 3 Jan: 63%</td>
<td>15 – 20 Feb: 56%</td>
</tr>
<tr>
<td>4 – 10 Jan: 62%</td>
<td>21 – 27 Feb: 55%</td>
</tr>
<tr>
<td>11 – 17 Jan: 61%</td>
<td>28 Feb – 5 Mar: 54%</td>
</tr>
<tr>
<td>18 – 24 Jan: 60%</td>
<td>6 – 12 Mar: 53%</td>
</tr>
<tr>
<td>25 – 31 Jan: 59%</td>
<td>13 – 19 Mar: 52%</td>
</tr>
<tr>
<td>1 – 7 Feb: 58%</td>
<td>20 – 26 Mar: 51%</td>
</tr>
<tr>
<td>8 – 14 Feb: 57%</td>
<td>27 Mar – 4 Apr: 50%</td>
</tr>
<tr>
<td>5 Apr – 9 May: 49%</td>
<td>8 – 12 Jun: 50%</td>
</tr>
<tr>
<td>10 – 18 May: 50%</td>
<td>13 – 16 Jun: 49%</td>
</tr>
<tr>
<td>19 May – 7 Jun: 51%</td>
<td>17 – 19 Jun: 48%</td>
</tr>
</tbody>
</table>

Moon Phases for Comet C/2015 V2 (1 March – 1 July) 2017:

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1: 0.09 (Near New Moon)</td>
<td>May 3: 0.52 (1st Qtr. Moon)</td>
</tr>
<tr>
<td>March 5: 0.47 (1st Qtr. Moon)</td>
<td>May 10 – 11: 1.00 (Full Moon)</td>
</tr>
<tr>
<td>March 12 – 13: 1.00 (Full Moon)</td>
<td>May 16 – 18: 0.48 (Last Qtr. Moon)</td>
</tr>
<tr>
<td>March 20: 0.54 (Last Qtr. Moon)</td>
<td>May 26: 0.00 (New Moon)</td>
</tr>
<tr>
<td>March 28: 0.00 (New Moon)</td>
<td>May 28: 0.00 (New Moon)</td>
</tr>
<tr>
<td>*April 4: 0.55 (1st Qtr. Moon)</td>
<td>June 1: 0.47 (1st Qtr. Moon)</td>
</tr>
<tr>
<td>*April 10: 1.00 (Full Moon)</td>
<td>Jun 9 – 10: 1.00 (New Moon)</td>
</tr>
<tr>
<td>*April 19: 0.52 (Last Qtr. Moon)</td>
<td>Jun 17: 0.53 (Last Qtr. Moon)</td>
</tr>
<tr>
<td>April 26: 0.00 (New Moon)</td>
<td>Jun 24: 0.00 (New Moon)</td>
</tr>
<tr>
<td>*April 19: 0.52 (Last Qtr. Moon)</td>
<td>July 1: 0.52 (1st Qtr. Moon)</td>
</tr>
</tbody>
</table>

*Note that the conditions for observing C/2015 V2 are not very favorable since the time from April 4 – 19 during the two weeks after perigee when the comet is expected to be at its brightest between perigee and perihelion and the time of perihelion passage. This is in spite of the fact that comet 41P will be a circumpolar comet!*

Meteor showers are composed of small fragmentations of rock and metal referred to as meteoroids in space and meteorites if such fragments survive entry into the Earth’s Atmosphere!

All meteor showers originate from the debris tail of comets and comet – like minor planets that orbit about the Sun. This material follows in a parallel path to the comet and will enter any planetary atmosphere forming meteorites due to ram pressure. Ram pressure is brought about by the compression of atmospheric gasses heating up to thousands of degrees Celsius in temperature radiating high thermal heat in a matter of milliseconds. This causes most small and some medium – size meteoroids to vaporize in just a few seconds. The trail left is a path of ionized gasses emitting short bursts of EM radiation especially visible light that lasts for only a few seconds to upwards of a minute before leaving behind a pathway of condensed gasses due to the interaction of materials between the meteor and a planet’s atmosphere during a rapid change in atmospheric conditions at extremely high altitudes!
Every swarm or grouping of meteoroids that enter the Earth’s atmosphere as a meteor comes from a known comet and travels in paths radiating from a position known as the radiant. All radiant positions are located in constellations for which the meteor is named!

*(Example: Eta Aquarids – Source: 1P/Comet Halley)*.

Meteorite swarms can be in more than one grouping that do not always intersect with the Earth’s orbit or take only a glancing blow to the Earth! The orientation of a comet’s dust tail and its anti–tail can have immediate effects on the location of debris with respect to the comet’s path around the Sun!
The strength of any meteor shower can vary due to the position of reentry and the distribution of meteoroids along a comet’s path! The meteoroids can either be distributed uniformly along the path or in clusters or swarms of varying amounts, size, and concentration of meteoroids.

These clumps due to interactions with the solar wind and slight gravitational effects within the solar system can cause these swarms to shift outside the direct orbital path of the comet! This can result in the same meteor shower varying in strength and duration over years or centuries as some of these swarms will miss or partly miss any head-on collision with the Earth!
### METEOR SHOWERS? WHERE DO THEY ORIGINATE?

#### A Basic Historical Chronology of the Perseids!

<table>
<thead>
<tr>
<th>Year</th>
<th>Period of Peak Activity</th>
<th>Peak Time during Max ZHR</th>
<th>Maximum ZHR (Zenith Hourly Rate)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>July 17 – August 24</td>
<td>August 11-12</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>July 17 – August 24</td>
<td>August 12–13</td>
<td>95</td>
<td>August 14 – New Moon</td>
</tr>
<tr>
<td>2014</td>
<td>July 17 – August 24</td>
<td>August 13</td>
<td>68</td>
<td>August 10 – Full Moon</td>
</tr>
<tr>
<td>2013</td>
<td>July 17 – August 24</td>
<td>August 12</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>July 17 – August 24</td>
<td>August 12</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>July 17 – August 24</td>
<td>August 12</td>
<td>58</td>
<td>August 13 – Full Moon</td>
</tr>
<tr>
<td>2010</td>
<td>July 23 – August 24</td>
<td>August 12</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>July 14 – August 24</td>
<td>August 13</td>
<td>173</td>
<td>Fainter meteors were washed out by a Gibbous Moon!</td>
</tr>
<tr>
<td>2008</td>
<td>July 25 – August 24</td>
<td>August 13</td>
<td>116</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>July 19 – August 25</td>
<td>August 13</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>July 17 – August 24</td>
<td>August 11 – 13</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>July 17 – August 24</td>
<td>August 12</td>
<td>&gt;200</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>July 15 – August 20</td>
<td>August 12</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>August 11</td>
<td>200 – 500</td>
<td>Outburst occurred two days before a Full Moon</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>August 11</td>
<td>~90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1864</td>
<td></td>
<td>&gt;100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1863</td>
<td></td>
<td>109 – 215</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1861</td>
<td></td>
<td>78 – 102</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1858</td>
<td></td>
<td>37 – 88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1839</td>
<td></td>
<td>165</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Any changes in the ZHR value when the radiant is at its maximum altitude above the horizon facing due south is in part due to the drifting of the meteoroid swarms or streams from a comet’s pathway! Note the 2006 event where the ZHR value was very low indicate that the swarms or streams where far from intersecting the Earth’s orbit while the ZHR in 1993 was a rare event in which a heave swarm or series of swarms took a direct hit on the Earth! The last time this happened was in 1860 and the next time will be in 2126 which occurs always one year after Comet Swift – Tuttle makes it 133 year orbital journey around the Sun!
Another factor in the quality of meteor showers:

Radiant Drift

Due to the shifting of the meteoroid swarms or streams from the main orbital path or trajectory of a comet source. The shifting of the radiant can result in meteor showers either having a high or low ZHR depending on the orientation of the radiant to the meteoroids. The solar longitude can also have an effect on the drifting of a radiant which can alter the density and intensity of a meteor shower if the Earth is not in perfect alignment with the meteoroid debris from a comet for any particular meteor shower!


Perseids Radiant Drift Map: 2016
Source: 109P/Swift - Tuttle

Active: 17 July – 24 August
Maximum: 12 August @ 13:00 – 15:30 UTC
Solar Longitude: 140° - 140.1°
ZHR: 150
Radiant Position: 48° or 3h 12m R.A. & +58° Dec.
Radiant Drift:
V = 59 km/s R = 2.2

Eta Aquariids Radiant Drift Map: 2017
Source: 1P/Halley

Active: 19 April – 28 May
Maximum: 6 May @ 02:00 UTC
Solar Longitude: 45° 30'
ZHR: 50 (periodic variation 40 – 85)
Radiant Position: 338° or 22h 32m R.A. & -1° Dec.
Radiant Drift:
V = 66 km/s R = 2.4
METEOR SHOWERS? WHERE DO THEY ORIGINATE?

International Meteor Organization (IMO) Terminology

Solar Longitude – the precise measurement of the Earth’s position in its orbit which is independent on the unexpected or fluctuating changes in the standard Julian calendar. All solar longitude values are given in the J2000 Epoch.

\( r \) – Represents the population index as a term which is computed from each shower’s meteor magnitude distribution.

- \( r \) between \((2.0 – 2.5)\) indicates a larger fraction of bright meteors than the overall average.
- \( r \) at \(3.0\) or greater implies a far richer concentration of fainter meteors than the overall average.

\( V \) – The atmosphere or apparent meteor velocity in \((\text{km/s})\). The velocities for meteors upon atmospheric entry has a range: \((11 – 72)\) \(\text{km/s}\) with \(40 \text{ km/s}\) being the overall averaged velocity value.

*ZHR – Zenith Hourly Rate

*For those of you who are not familiar with the term ZHR it is calculated value on the estimated maximum number of meteors entering the atmosphere that anyone would be able to observe from the radiant in ideal, perfectly dark, clear skies. There are times when the ZHR which is the number of meteors observable per hour can be greater than predicted for extreme conditions than can occur in the time period of an hour or less. In less than ideal conditions the reported ZHR values can be below the predicted ZHR for an observed meteor shower.