

A Separate Reality

by Dick Suiter

We often fire up the *Stellarium* planetarium simulator and believe whatever it tells us uncritically. What we should keep in mind is that *Stellarium* is a product of human imagination and is as subject to error as any software is. Particularly hard to detect are those errors derived from operating otherwise correct parameters out of the range where they apply. However, sometimes it can be caused by a mere typo. I recently came across a photo I had scanned of comet Halley. I was unsure of what day exactly I had taken it so I ran *Stellarium* to verify it.

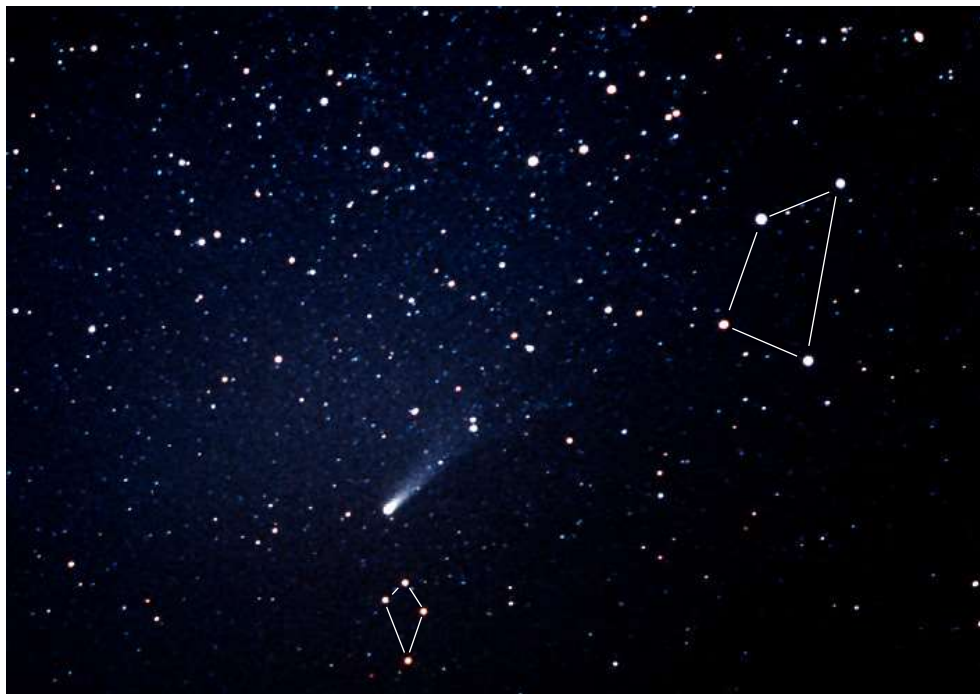


Figure 1: This is the whole picture I was trying to match with *Stellarium* output. I have drawn lines in the handle of the Teapot asterism of Sagittarius and a little kite-shaped figure that appeared below the comet, so readers know where they are. 50mm with 2x tele-extender on hand-driven barn door.

The resulting search yielded the unsatisfactory result in Figure 2. I really can't pick it much better than plus or minus a couple days, because the comet is so far from the correct answer. Another thing is that I don't remember it being so late in the morning or so early in the year. The picture was about 4 AM, but *Stellarium* would us wait until 6AM on 5 Feb 86 for the kite to clear the horizon.

Then, I remembered an astrophotography album I had made a long time ago. I looked at it, and sure enough, I had a labeled copy of this photo in it. The label said 18 Mar 86. I changed *Stellarium* to Mar 18 and it showed the comet in Scorpius, which is even worse.

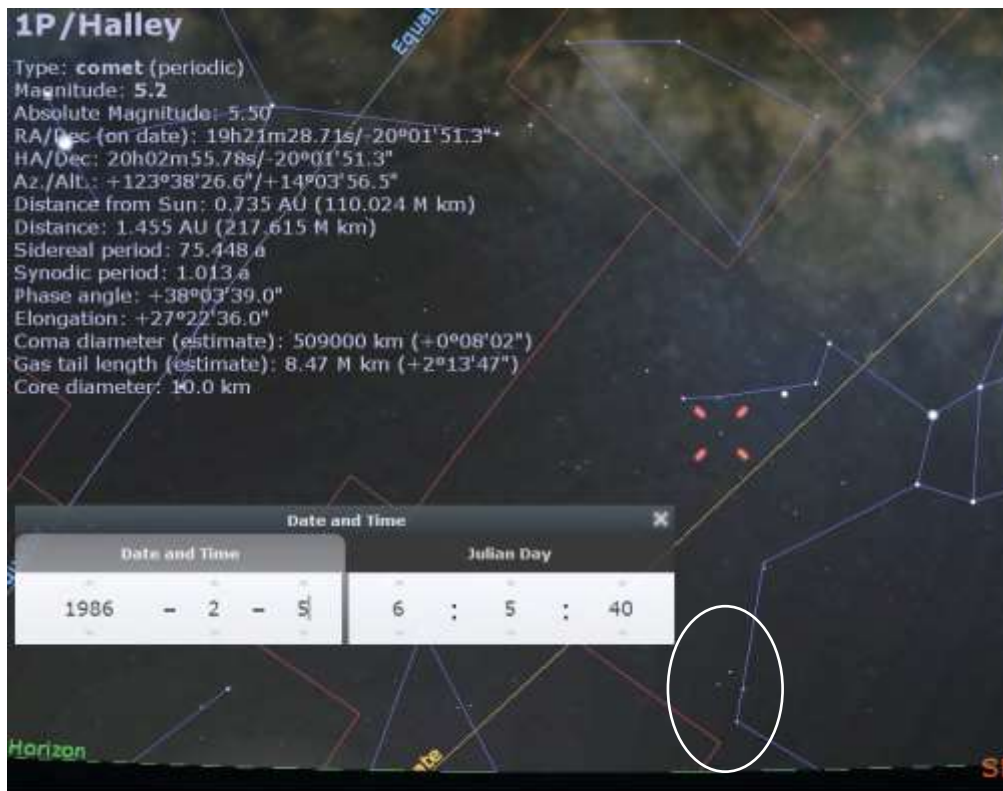


Figure 2. Halley passes far above the little kite (marked by oval) in *Stellarium*. Clearly, *Stellarium* or its orbital elements is not giving the correct answer.

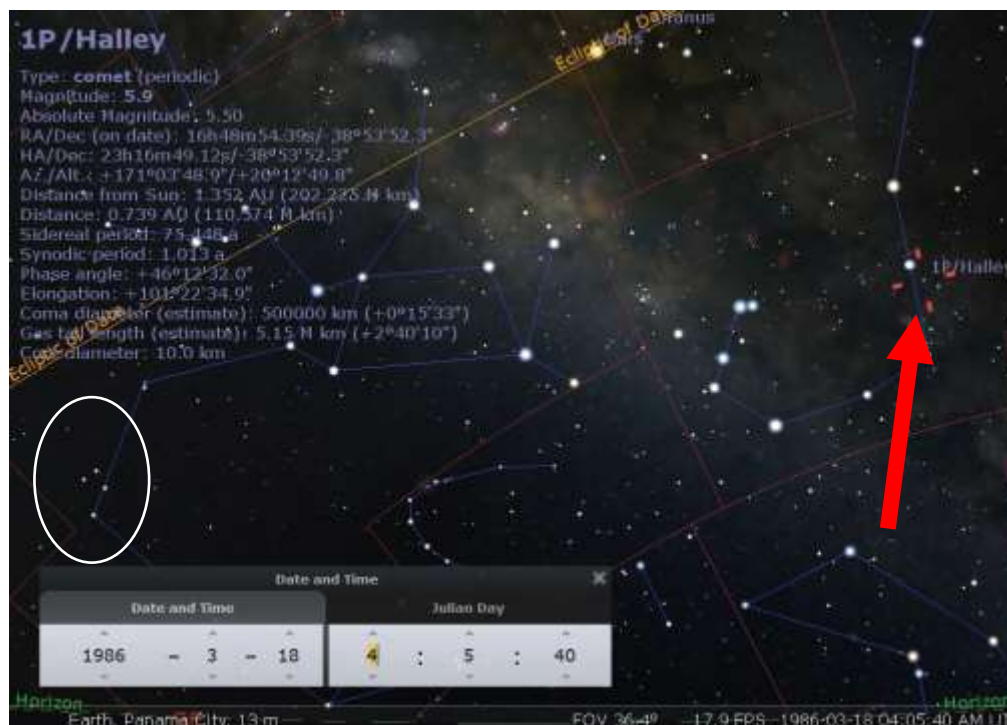


Figure 3. Even worse is the *Stellarium* prediction for 18 Mar 86, which has Halley in Scorpius! The kite is in the oval. This is in direct contradiction to the real data.

How does *Stellarium* plot comets? In the default initialization directory C:\Users\"username"\AppData\Roaming\Stellarium\data there is a file called ssystemminor.ini. It stores data describing the minor body orbits. A lot of this isn't used to calculate position, but 6 orbital elements are. If we look at the Table 1 snip for comet 1P/Halley (not Halley 2061, which is the next appearance), the Julian day for 1986 perihelion translates to Jan 21 1986. **The actual date of perihelion was Feb 9, 1986.** Now, perihelion can change a little if we do the calculation for a different epoch (i.e., time) according to which ellipse best fits the orbit at that point (see Figure 4), but I don't think it would change 18 days. None of the other elements are precisely correct either, but they are by no means as bad. Note: orbit_epoch is not recorded.

Table 1. Part of the current default ssystem.minor.ini file

```
[1phalley]
...
model = 1682q1halley_MLfix.obj
name = 1P/Halley
orbit_ArgOfPericenter = 111.2761
orbit_AscendingNode = 58.3371
orbit_Eccentricity = 0.966169
orbit_Inclination = 162.2979
orbit_PericenterDistance = 0.604593
orbit_TimeAtPericenter = 2446452.6826967592
[1/21/86?] ← ADDED COMMENT TRANSLATING JULIAN DAY OF TIME AT PERIHELION
orbit_good = 2000
orbit_visualization_period = 27555.47042930016
...
```

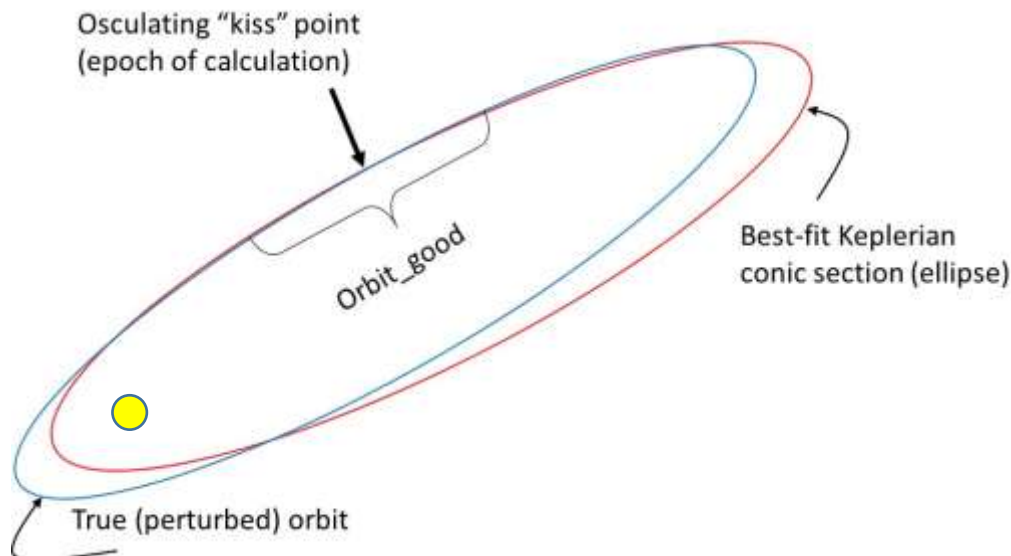


Figure 4. The way that osculating orbital elements can give different results than true dynamical orbits, taking account of other forces than the central one. The epoch of the osculating elements are calculated far from the perihelion.

To repair the file (and do it correctly) choose the Configuration window (the little menu to the left side which looks like a wrench) and find the Solar System Editor of the plug-ins. If it doesn't have the "load at startup" invoked, turn it on and restart the program. Inside Solar System Editor again, request configuration, and view the next menu (Fig 5a). Switch the the Solar System tab (Fig. 5b). Note that comet Halley is in there, but you needn't do anything about it on that screen. Hit the

"Import orbital elements in MPC format" bar at the bottom of the screen. Type in P/Halley and search until you see the entry in 5d. Mark it and Add the Object.

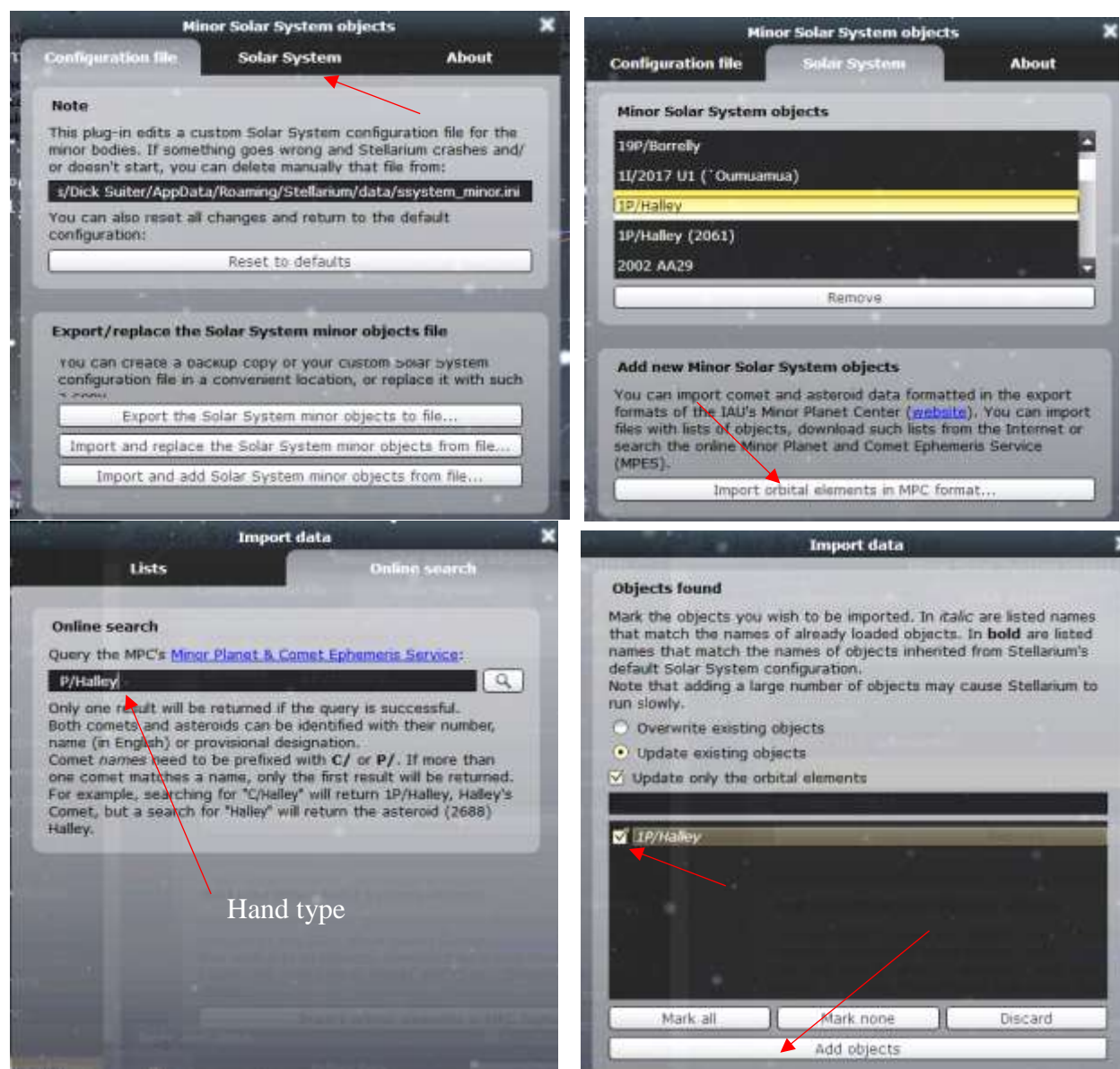


Figure 5. Four screens in the solar system editor.

The changed values in appdata\roaming\stellarium\ssystemminor.ini appear at the end of this paper (under the suggested revised elements in Table 2). I am somewhat confused that the program generating this *Stellarium* format doesn't have the epoch (date) for which the osculating elements are chosen stated explicitly. The orbit is declared good for 1000 days surrounding that date, but the date of the epoch is *not there*. Other objects have an orbit_epoch parameter, but I don't see it here. I would think that when the time period exceeded the orbit_good window around the orbit_epoch time, the object would go dark or at least be marked with an asterisk in *Stellarium*.

A site that worked was

<https://www.minorplanetcenter.net/iau/MPEph/MPEph.html>

which is possibly the page the Solar System Editor connected to. The ephemeris calculation result appears in Figure 6. Indeed, some sort of *Stellarium* auto-input may have requested information from this site, and then translated it to the format used internally by *Stellarium*.¹

The elements reference an *Astronomical Journal* paper of 1989, which has slightly different values because they are calculated for 1950.0 coordinates.² But note the epoch for the calculation is close to perihelion at Feb 19, 1986. At the end of Fig. 6, I chose an alternate epoch (= 18 Mar 1986) to calculate the elements, but the elements shift little in a month. Another source gives elements very close to those in Figure 6.³

1P/Halley

Epoch 1986 Feb. 19.0 TT = JDT 2446480.5
T 1986 Feb. 9.4590 TT Yeomans and Chodas
q 0.587104 (2000.0) P Q
n 0.0129692 Peri. 111.8657 +0.5638912 -0.7835057 T = 2446470.95895 JDT
a 17.941564 Node 58.8601 -0.8243995 -0.5153195 q = 0.5871036
e 0.967277 Incl. 162.2422 -0.0489103 -0.3472241 Earth MOID = 0.06550 AU
P 76.0

Perturbed ephemeris below based on elements *AJ* 98, 1083.

0001P													
Date	UT h m s	R.A. (J2000)	Decl.	Delta	r	El.	Ph.	m1	Sky Motion "/min P.A.		Object Azi. Alt.		Sun Alt.
1986 03 16	100000	19.9497	-23.323	0.901	0.938	59.1	65.4	3.4	2.30	226.3	305	+10	-25
1986 03 17	100000	19.9003	-23.971	0.876	0.953	60.9	65.7	3.4	2.43	226.5	307	+11	-25
1986 03 18	100000	19.8476	-24.653	0.851	0.969	62.7	66.0	3.4	2.58	226.8	308	+12	-24
1986 03 19	100000	19.7912	-25.372	0.825	0.984	64.6	66.1	3.5	2.73	227.1	310	+13	-24
1986 03 20	100000	19.7305	-26.131	0.800	0.999	66.6	66.2	3.5	2.91	227.5	312	+13	-24
1986 03 21	100000	19.6649	-26.933	0.775	1.014	68.6	66.1	3.5	3.10	228.0	313	+14	-24
1986 03 22	100000	19.5938	-27.782	0.750	1.030	70.7	65.9	3.6	3.32	228.5	315	+15	-23

Elements at other epoch(s):

Epoch (TT/JD)	T (TT/JD)	Peri.	Node	Incl.	e	q	a	Epoch (TT)
2446507.50000	2446470.9589749	111.86579	58.86015	162.24218	0.9672771	0.5871043	17.94172	1986/03/18.00

Angular elements are J2000.0, perihelion distance (q) and semi-major axis (a) are in AU.

Figure 6. Output of Minor Planet and Comet Ephemeris Service (Perihelion is Feb 9 1986) Moon phase is beyond page to the right as it is not relevant.

Figure 7 shows the match that *Stellarium* now gets with the elements below in Table 2.

¹ The server that stores this calculator is not always on line. Give it time.

² D. K. Yeomans and P. W. Chodas, An Asymmetric Outgassing Model For Cometary Nongravitational Accelerations, *Astronomical Journal* (98) no. 3, pg. 1083, Sept 1989

³ *Fundamentals of Celestial Mechanics, 2nd Ed.* J.M.A. Danby, p.447, Willmann-Bell, Inc., Richmond VA, 1992.



Figure 7. Left: part of my 18 Mar 1986 photo. Right: *Stellarium* output with corrected 1986 elements.

I downloaded elements from a list of comets at Gideon van Buitenen's site. I also downloaded another two canned element files from the Minor Planet Center. I tried all three on 18 Mar and they were all between Scorpius and Sagittarius — a little closer to the camera data but still a long way off. Suspecting I had a corrupt installation, I completely erased *Stellarium* from my system and reinstalled it, being sure to wipe out all *.ini files. No change. I looked at the on-line planetarium at <https://stellarium-web.org/> and it has the comet erroneously placed between Sagittarius and Scorpius again on 18 Mar 86, but that's likely just because it uses similar files.

I copied a set of (presumably) 1982 elements from `ssystem_1000comets.ini`, a datafile having extra comet material too cumbersome to hold in *Stellarium* all the time. I also hand-transferred the orbital elements from *JPL Small-Body Database Browser*, which has the orbit epoch calculated in 1994, and both results plotted pretty well, but the elements are somewhat different and the JPL elements (with epoch further away) give worse results. See Figure 8, which compares the result of the 1982 epoch in `ssystem_1000comets` to the 1986 value downloaded from the Minor Planet Center. The others are much farther away. I have compared this photo with diagrams published in the March 1986 issue of *Sky and Telescope*. I can't really read the published chart well enough to distinguish between the 1982i and 1986-epoch MPC, but I can easily reject the JPL1994 calculation, as well as the ones over in the next constellation.

This behavior is — to say the least — distressing. Trifling differences between the elements shouldn't be easily detected in calculations of the sort that *Stellarium* makes. To find massive errors in the last appearance of history's most famous comet doesn't give you much assurance that the other lesser known objects are correct either. If I were to guess at the cause, I would say that it



Figure 8. Comparison of three sets of orbit elements (two with perihelion on Feb 9 -- the MPC fresh download of the elements of Figure 1 and the 1982i elements from the 1000comets file) and one with perihelion on the 5th (JPL's). Only the MPC elements calculated for 1986 matches the data photo to left.

is mostly variation in the time of perihelion passage, but I don't know the details. These osculating elements shouldn't continue on into the indefinite past or future; they're good only around the time (or the "epoch") that the curves touch the real orbit. However, they should be a lot closer than a constellation away. I suspect that the error is not *Stellarium*'s fault but an error that originates in the files distributed at the Minor Planet Center (perhaps a typo). It doesn't affect the on-line calculator of the same Minor Planet Center, it seems. I compared the MPC 1986 epoch orbit with two other pictures on the recent Alan Hale blog site:

<https://www.rocketstem.org/2020/03/07/ice-and-stone-comet-of-week-11/>

The 1986 elements matches the Mar 7, 1986, photo by Hale himself, but doesn't match the alleged Mar 13 date of the other photo by Dennis Mammana. However, it places the comet precisely at that point for Mar 22, which makes me think that record keeping is faulty for the Mammana photo, or perhaps it's just a typo in the blog.

The stars in the in the following slideshow that could be identified, also matched the MPC calculation.

<https://www.youtube.com/watch?v=WKrK0GS3gTU>

SUGGESTIONS

And what would I recommend the High Elves at the Stellarium github site do? Two things:

- 1) Replace the default orbital elements of Halley with the ones downloaded from MPC in Table 2. It makes no sense to use as a default a set of elements those calculated for a distant epoch when the comet is far from the Sun. *Use elements calculated for the epoch when Halley was visible for the default.* If, for some reason, it is desired to preserve the present elements under the name 1P/Halley, rename the information in Table 2 to "1P/Halley (1986)."

Table 2. Epoch 1986 MPC revised elements matching contemporary photos, adapted to *Stellarium* format.

```
[1phalley]
orbit_good = 1000
orbit_Eccentricity = 0.967277
orbit_TimeAtPericenter = 2446470.958888889
name = 1P/Halley
orbit_ArgOfPericenter = 111.8657
albedo = 0.1
type = comet
absolute_magnitude = 4
orbit_Inclination = 162.2422
dust_brightnessfactor = 1.5
dust_lengthfactor = 0.4
slope_parameter = 6
orbit_visualization_period = 27758.20106745674
orbit_PericenterDistance = 0.587104
dust_widthfactor = 1.5
orbit_AscendingNode = 58.8601
coord_func = comet_orbit
radius = 5
```

- 2) Start recording the orbit_epoch for which the elements are calculated and define a window with the orbit_good parameter to note when the osculating orbital elements are appropriate. A simple asterisk on plots outside this window would help, but I would prefer not even to see the improperly displayed comet. If astronomers want to investigate the position of a comet outside the orbit_good window, they are probably savvy enough to enlarge this parameter by hand.

What do we do when we play back astronomical events of history and do not have data with which to compare. We take a gamble. I think the reason comet errors can persist so long is because people may remember the comet but they don't remember the particular stars it was photographed against. The best thing to do if you make a planetarium simulator calculation of *Stellarium* or indeed any other program (and don't have real data) is to compare it with contemporary news graphics such as appear in *Sky and Telescope*. Lacking that, the second best thing is to compare a number of independent sources. If you are doing deep historical calculations where there are few reliable contemporary records, be very careful of making broad pronouncements.

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Addendum: I reported it to the people at the Stellarium Github site and they agreed that it could be confusing to users. Someday they will perhaps use the Orbit_Epoch parameter so the calculation uses only the Keplerian conic section near the times they are meant to apply. In the meantime they suggest that the user load the information contained under Halley in the `ssystem_1000comets` database.* This procedure is especially mysterious to the unsophisticated user, and requires a lot of digging in the manual to uncover even the existence and purpose of this database. One would hope that they would at least modify the manual to warn user about this problem, and point out that you need to use the 1000comets database for historical comet orbits.

* It is the close-to-correct 1982III calculation above. I don't know the source of these parameters. Mr. Yeomans had a more accurate set both before and after.