Getting new CCD images for Suer-LOTIS

Here's information regarding how to request observations of your asteroid.

The Laplace method for getting orbital elements needs three measurements of the position. There are six unknown orbital elements (matching the six degrees of freedom of a single particle in Newtonian mechanics x, y, z, & vx, vy, vz), to find these six numbers we need a minimum of three epochs (two angles are measured each time).

We already have multiple epochs for several asteroids, but they may not be ideally spaced in time. If you use the data from late September (25-28) then only one or two days elapses between the measurements. The night-to-night changes in the position are relatively small, and the fractional error (angle moved/error in position) will be large. If you leave a longer interval, then the angle is larger and your fractional precision increases. It would be better to use 9/25, 10/2 and 10/21 (intervals of 7 and 19 days).

If we get some data this week, then we can establish another baseline of about 15 days. If you wait too long there is another potential problem---we used a Taylor series to describe the motion, which is equivalent to assuming that the velocity and acceleration are constant. In a Keplerian orbit neither of these is exactly constant and the approximation is only valid over a limited interval.

Here are the steps:

1) Choose which asteroid for which you need final epoch data.

2) Choose the date of the observation. The Super-LOTIS telescope observations are scheduled by the local date on the evening of which you want data. So even if your observations are scheduled after midnight, you need to note the date of the previous evening.

3) Use the JPL HORIZONS to predict the approximate position of the asteroid for the night of your choice. Be sure to use the correct settings:

a) Ephemeris Type: OBSERVER

b) Target Body: Asteroid 10 Hygiea [for example]

c) Observer: Kitt Peak [695]

d) Time Span: Start=2008-11-05, Stop=2008-11-06, Step=1 h
[be sure to compute the position hourly and note that your request is in UT not local time]

e) Table Settings: [be sure to select Astrometric RA/DEC in HMS/DMS and J2000]

Here's the output from this example:

```
*******************************************************
 Date__(UT)__HR:MN     R.A._(ICRF/J2000.0)_DEC a-mass
*******************************************************
$$SOE
 2008-Nov-05 00:00 *m  05 00 11.56 +25 44 49.0   n.a.
 2008-Nov-05 01:00 Nm  05 00 10.16 +25 44 47.1   n.a.
 2008-Nov-05 02:00  m  05 00 08.74 +25 44 45.2   n.a.
 2008-Nov-05 03:00  m  05 00 07.30 +25 44 43.3  6.902
 2008-Nov-05 04:00  m  05 00 05.85 +25 44 41.5  2.945
 2008-Nov-05 05:00  m  05 00 04.38 +25 44 39.6  1.884
 2008-Nov-05 06:00     05 00 02.90 +25 44 37.7  1.424
 2008-Nov-05 07:00     05 00 01.40 +25 44 35.7  1.188
 2008-Nov-05 08:00     04 59 59.89 +25 44 33.7  1.064
 2008-Nov-05 09:00     04 59 58.38 +25 44 31.5  1.011
 2008-Nov-05 10:00     04 59 56.86 +25 44 29.3  1.014
 2008-Nov-05 11:00     04 59 55.34 +25 44 27.0  1.073
 2008-Nov-05 12:00     04 59 53.83 +25 44 24.6  1.205
 2008-Nov-05 13:00 N   04 59 52.32 +25 44 22.2  1.457
 2008-Nov-05 14:00 *   04 59 50.82 +25 44 19.7  1.952
 2008-Nov-05 15:00 *   04 59 49.34 +25 44 17.1  3.127
 2008-Nov-05 16:00 *   04 59 47.86 +25 44 14.5  7.928
 2008-Nov-05 17:00 *   04 59 46.40 +25 44 12.0   n.a.
 2008-Nov-05 18:00 *   04 59 44.95 +25 44 09.4   n.a.
 2008-Nov-05 19:00 *   04 59 43.51 +25 44 07.0   n.a.
 2008-Nov-05 20:00 *   04 59 42.08 +25 44 04.5   n.a.
 2008-Nov-05 21:00 *m  04 59 40.65 +25 44 02.2   n.a.
 2008-Nov-05 22:00 *m  04 59 39.21 +25 43 59.9   n.a.
 2008-Nov-05 23:00 *m  04 59 37.78 +25 43 57.7   n.a.
 2008-Nov-06 00:00 *m  04 59 36.34 +25 43 55.6   n.a.
$$EOE
*******************************************************
```

4) Choose the time that you want the images to be taken.

You have to pick a time when the asteroid is above the horizon, and ideally close to the zenith. Note that in this example I've requested that the "airmass" be tablulated. We want this number to be greater than 2 (see Lab. #3 handout). In this example the best time would be 09:00 UT.

Arizona time (MST) is 7 hours behind UT, so 09:00 UT corresponds to 02:00 AM (MST). Moreover, the UT date 2008-Nov-05 would be scheduled on the evening of Nov 4, local time.

This asteroid (10 Hygiea) is only moving about 1 arc minute per day, so if you get the wrong day it the object would still fall within the 17' x 17' field of view. This is not always going to be true, so double check that you have the right date!

5) Format the request. For example, here's the request that I used to get the data on the evening of 10/21:

```
Evening of 10/21 local

05 00 083307.96 +184836.2 2000.0 20 3 RI : Asteroid 27 Euterpe V = 11.3
02 00 050019.62 +205525.8 2000.0 20 3 RI : Asteroid 21 Lutetia V = 11.6
02 00 050609.44 +255203.5 2000.0 20 3 RI : Asteroid 10 Hygiea V = 11.6
01 00 025936.60 +113350.4 2000.0 10 3 RI : Asteroid 9 Metis V = 9.9
```

Column 1 & 2: The time that you want the image taken---times are local 24 hour hour clock, not UT (MST is UT - 7 hours). This is only a guide---the automatic scheduler will try to fit this in to the nearest hour.

Column 3 & 4: RA (hours, minutes, seconds) and Dec (sign, degrees, minutes of arc, seconds of arc) with no spaces between hours, minutes, seconds and degrees, minutes, seconds, with any number of decimal digits (although two places for RA seconds and one for Dec seconds is plenty of precision).

Column 5: The equinox. You should request J2000 from JPL and so this number should be 2000.0 for all objects.

Column 6: The exposure time. This should be 20 seconds for the fainter asteroids (11 th. magnitude) and 10 seconds for the brighter objects (9 th. magnitude).

Column 7: Number of repeats. A single image may suffer from cosmic ray hits. Try three exposures.

Column 8: List of filters to make the observation. This example requests the R filter and the I filter.

Column 9: A colon followed by some information about the target, e.g., the name and the estimated brightness .

When you have made up your target list email to me and I'll send off your request.