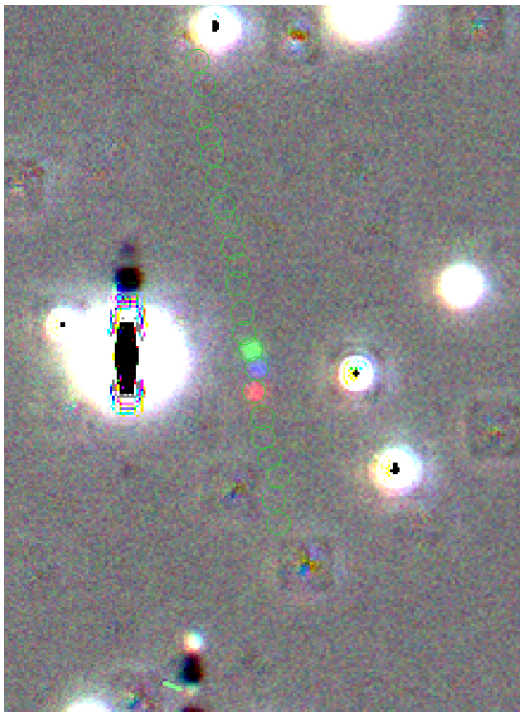
Photometry and Astrometry on Asteroids Using Matplotlib Library

To prepare data to run through photometry and astrometry scripts, I opened telescope images in SAO ds9 and placed circular regions of the same size around each area where an asteroid appeared. Making sure the regions were in chronological order based on when the images were taken, I tracked a single asteroid and added a region for every image taken over the course of one night (shown below).



Once I finished adding all regions for an asteroid, I added the asteroid's information by hand to the `asteroid_tracking.txt` file in the following format: asteroid_name, chip, date, first_image.

In order to run the `astreg2phot.sh` script, the following files need to be downloaded:

- Interp files
- Kernels
- MISHAPS_F1_r.refkernels.tar.gz
- MISHAPS_F1_*_r.ref.fits (the asterisk is the chip)
- MISHAPS_F1_r.good.holdings

Then, I run the astrometry script `astreg2phot.sh` from the directory with data with the following command:

```
~/cfht-pip2/astreg2phot.sh <ast_regfile> asteroid_tracking.txt
```

The `ast_regfile` is the name of the region file for the asteroid and `asteroid_tracking.txt` is the header file.

Running the `astreg2phot.sh` script also runs a second script, `astreg2phot2.sh` that uses optimized positions to create potentially better astrometry together. Using the above command gives all of the files needed for photometry and astrometry. However, there are several scripts that can be run separately, if needed.

Summary of Scripts

`convert.sh`

Creates necessary files and file formats for `all_fits.py`, `to_mpc.py`, `all_asteroids.py`, `astreg2phot.sh`, and `astreg2phot2.sh`

Command:

```
~/cfht-pip2/convert.sh <asteroid_name> <iteration>
```

This script must be run before running all of the files listed above.

`all_fits.py`

Command:

```
python3 ~/cfht-pip2/all_fits.py <asteroid_name> <iteration>
```

The iteration input is either 1 or 2. The iteration is 1 when using the un-optimized positions and 2 when using the optimized positions.

This script uses output from `convert.sh` to create all necessary photometry and astrometry graphs as well as the residuals to compare the unoptimized and optimized positions.

`all_asteroids.py`

Run from directory containing the following two files:

```
MISHAPS_F1.vertices
MISHAPS_F1.centers
```

Command:

```
python3 ~/cfht-pip2/all_asteroids.py
```

This script uses output from `convert.sh` and plots the asteroid tracks in reference to the chip borders. Used to find linked asteroids.

`astreg2phot.sh`

Run from directory containing data

Command:

```
~/cfht-pip2/astreg2phot.sh <ast_regfile> asteroid_tracking.txt
```

Runs `all_fits.py` and outputs all necessary astrometry and photometry plots for both unoptimized and optimized positions.

`astreg2phot2.sh`

Run from directory containing data

Command:

```
~/cfht-pip2/astreg2phot.sh <ast_textfile> asteroid_tracking.txt
```

Runs `all_fits.py` for optimized positions and outputs all necessary astrometry and photometry plots for optimized positions only.

`<ast_textfile>` is a text file in the format `<asteroid_name>.txt` that was output from the unoptimized `astreg2phot.sh` script (specifically, the `all_asteroids.py` and `convert.sh` scripts).

`linkast.py`

Run from directory containing data for the first asteroid (chronologically) and providing the path to the second asteroid.

Command:

```
python ~/cfht-pip2/linkast.py <ast1name> <path_to_ast2>/ast2name
```

Plots fitted data for astrometry and photometry of two linked asteroids.

`linkastgen.py`

This is a second script to link asteroids that accepts any number of asteroids.

Command:

```
python ~/cfht-pip2/linkast.py <ast1name> <path_to_ast2>/ast2name ...
```

Plots fitted data for astrometry and photometry of two or more linked asteroids.