A Preliminary Analysis of the Astrometric Asteroid Observations in the UCAC

James L. Hilton
Astronomical Applications Dept.
U.S. Naval Observatory
Overview

- Analysis of UCAC observations of three asteroids found.
  - $\sigma_{\text{RA}} = 60$ mas $\quad \sigma_{\text{dec}} = 90$ mas
  - The two smaller asteroids show evidence of unmodeled perturbations.
  - Eight of 49 observations of (2) Pallas show a puzzling systematic offset.
Asteroid Observations in the UCAC

While the UCAC was at Cerro Tololo Inter-American Observatory it made 5864 observations of asteroids. In particular:

- 49 observations of (2) Pallas over 3 oppositions
- 47 observations of (692) Hippodamia over 2 oppositions
- 10 observations of (752) Sulamitis over 2 oppositions
Asteroid Observations in the UCAC

- The accuracy of these observations compared to ephemerides is approximately 50 mas in R.A. and 80 mas in dec.
- Although observations are of high accuracy they cannot be used for significant improvement in the asteroids’ ephemerides.
The Effect of Unmodeled Asteroid Perturbations on the Ephemerides of Mars

### Characteristic Parameters

<table>
<thead>
<tr>
<th>Asteroid</th>
<th>$a$ (AU)</th>
<th>$e$</th>
<th>$i^*$ (deg.)</th>
<th>$r$ (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2) Pallas</td>
<td>2.771</td>
<td>0.231</td>
<td>34.84</td>
<td>524</td>
</tr>
<tr>
<td>(692) Hippodamia</td>
<td>3.382</td>
<td>0.171</td>
<td>26.10</td>
<td>45</td>
</tr>
<tr>
<td>(752) Sulamitis</td>
<td>2.463</td>
<td>0.074</td>
<td>5.95</td>
<td>66</td>
</tr>
<tr>
<td>(1) Ceres</td>
<td>2.767</td>
<td>0.078</td>
<td>10.59</td>
<td>952</td>
</tr>
<tr>
<td>(4) Vesta</td>
<td>2.362</td>
<td>0.088</td>
<td>7.13</td>
<td>522</td>
</tr>
</tbody>
</table>

* Inclination to the ecliptic.
(692) Hippodamia

(O – C)s for (692) Hippodamia

\[ \pm 1\sigma \]
(692) Hippodamia (continued)

(O – C)s in Right Ascension for (692) Hippodamia

(O – C)s in Declination for (692) Hippodamia

±1σ
Hippodamia is too small for its disk to be significant.

Scatter in positions is apparently primarily caused by differences between the observed and predicted orbits.

- \( \sigma_{\text{RA}} = 100 \text{ mas} \quad \sigma_{\text{dec}} = 210 \text{ mas} \)

- These values are about 42% the RMS uncertainties of the observations used to determine the ephemeris.

- Hippodamia has probably been perturbed, but by what? When?

- There is only a single position in declination that is discordant.
(752) Sulamitis

(O – C)s for (752) Sulamitis
(752) Sulamitis
(continued)

(O – C)s in Right Ascension for (752) Sulamitis

(O – C)s in Declination for (752) Sulamitis

\[\pm 1\sigma\]
Sulamitis is too small for its disk to be significant.

Scatter in positions is apparently primarily caused by differences between the observed and predicted orbits.

- $\sigma_{\text{RA}} = 50 \text{ mas}$
- $\sigma_{\text{dec}} = 80 \text{ mas}$

These values are about 16% the RMS uncertainties of the observations used to determine the ephemeris.
(2) Pallas

Pallas is large enough to produce a visible disk in Space Telescope images.

From: Schmidt et al. 2009, Science, 326, 275
(2) Pallas (continued)

(O - C)s for (2) Pallas

\[ \Delta \alpha \]

\[ \Delta \delta \]
(2) Pallas (continued)

(O - C)s in Right Ascension for (2) Pallas

(O - C)s in Declination for (2) Pallas

JD-2450000 ±1σ
(2) Pallas (continued)

- For all 49 observations
  - $\sigma_{RA} = 220 \text{ mas} \quad \sigma_{dec} = 130 \text{ mas}$

- If the eight anomalous observations are discarded
  - $\sigma_{RA} = 60 \text{ mas} \quad \sigma_{dec} = 90 \text{ mas}$
  - These values are about 17% the RMS uncertainties of the observations used to determine the ephemeris.
  - The uncertainty in position is approximately $1/2 - 1/3$ Pallas' radius.
What is the cause of the eight non-random outliers?

- Albedo markings?
  - But the center of light is outside Pallas’ disk.
- Background star?
  - But Pallas is a moving object
- Satellite?
  - Expect outliers to form a “band”.
- Problem with observation or reduction?
  - Expect similar results for other objects.
Summary

- UCAC asteroid positions appear to have an accuracy of about 50 – 80 mas.
- Much of the uncertainties in position are likely from perturbations of the asteroids.
- Eight of 49 Pallas observations have an unexplained systematic error.