Period search

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Several approaches available

Context: Astrometric binary orbit determination

Difficulty: Projection effect due to changing scanning direction

Period search:

- Model fitting: non linear;
- PDM: few data & need to sort for all trials;
- Power spectrum (e.g. Scargle 1982): equivalent to a LS fit with the assumption of a sine curve.

The goal is to separate the period from the other parameters!

Test material

- 1,000 systems with large S/N astrometric wobble caused by a companion
- uniform period distribution between 10 days and 5 years
- uniform distribution of the the eccentricity over 0–1.
- likely NSL

Warning: even when $e = 0$, Scargle-like method is NOT equivalent to fitting a circular orbit.

Popular wisdom

1. Minimizing the wrong quantity solves the problem of someone else, not yours.
2. Minimizing the right quantity wrongly does solve your problem but the result is plain wrong.
3. Maximize thinking before minimizing anything else.
4. Engage brain before engaging least-squares.

Investigated approaches

- a sparse grid with fifty trials of P uniformly distributed over 10 days – 5 years; ten trials of e over $[0, 1[$ and fifty of T over 0 – P.
- circular orbits with P^{-1} uniformly distributed over 10 days – 5 years, the step is the inverse of N times the mission duration. N is the oversampling parameter set to 20 in this case.
- a dense grid with the same distribution of P as previously ($N = 10$) coupled to ten trials of e and ten of T (over 0 – P).
- a combined approach where the dense grid is used if and only if no circular orbit yields a valid solution (F2-based decision).

Results

- the sparse grid failed in 34 cases (17 if the step on $\Delta P/2$)
- 24 failures w/circular orbits,
- the dense grid on 10 systems
- the combined grid only 5 times.

Computation time

- The circular approach is about 90 times faster than the dense grid
- The combined approach is still 25 times faster.

Conclusions & perspectives

- Even if most orbits are not circular, the circular approach alone yields a valid solution 97% of the time.
- The success rate reaches 99.5% by screening those 3% with a dense grid.
- This compromise is valuable both in terms of success rate and of speed (circular fit always faster).

Soon, new results based on 100k stars w/ wide range of S/N.