# Catalogues and parameters of orbital binaries

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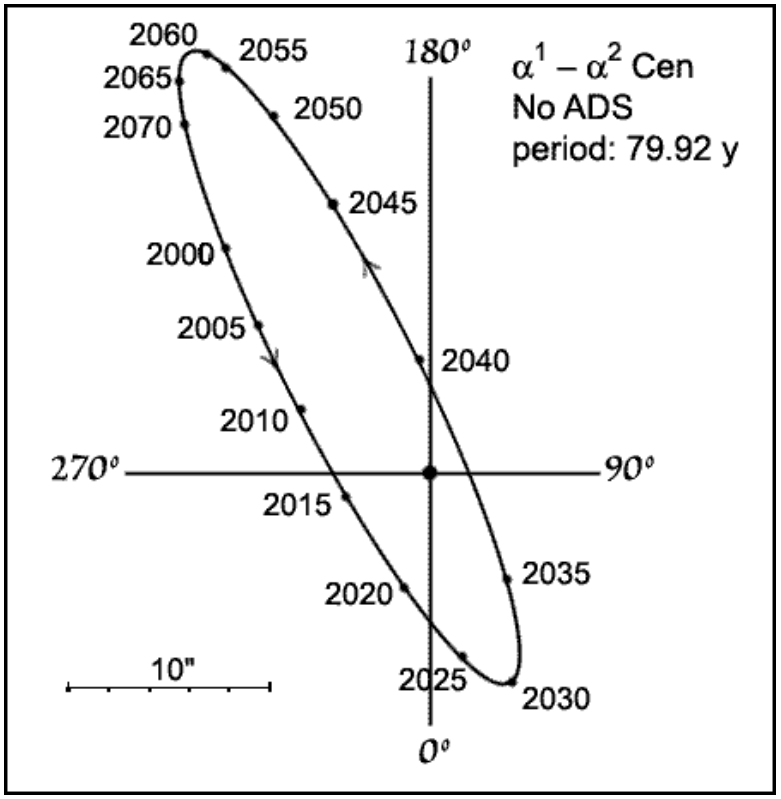
# Term

- Orbital binary is a visual binary with known orbital elements (and known distance)



# Outline

- Goals
- Compilation of a list of orbits
- Construction of refined list of pairs
- Parameter distributions

# Goals

- Construct a largest list of orbital binaries, containing, beside orbital elements, magnitudes and spectral types of components, distances and indication on spectroscopic and eclipsing phenomena
- Estimate dynamical masses of orbital binaries, compare them with photometric and spectral masses, and make preliminary conclusions on distribution of systems along principal parameters (mass, P, a, e, …)

# Existing catalogues

- ORB6 (Hartkopf et al., 2000 pairs): no spectral classification; no parallax; P or/and a values sometimes absent; about fifty misprints/errors (most of them are format variances)
- OARMAC (Docobo et al., 1700 pairs): poor availability; uncomfortable format; no orbital parameters' uncertainty; pair names are often written incorrectly; outdated photometry; about a hundred misprints/errors

# General “drawbacks” of existing lists

- They are not exhaustive
- They often contain several orbits per pair: it is not convenient for statistical studies

# Step 1:

- Compilation of a list of ORBITS

# Compilation of a list of orbits

- Join the ORB6 and OARMAC. Keep systems without parallax, but remove systems without P, a
- Get recent photometry and spectral classification from WDS
- Get data from SIMBAD (see next slide)

# Data from SIMBAD

- Coordinates: to estimate interstellar extinction (it is an important value for photometric mass calculation)
- Magnitude(s): if absent in original catalogues and WDS
- Spectral type(s): if absent in original catalogues and WDS
- Parallax with uncertainty
- Indication on spectroscopic and eclipsing nature

# Format

- Identification: No in ORB6, No in OARMAC, WDS, Name, HIP, ADS
- Number of pair in system, number of orbit for pair
- Magnitudes, spectral types, parallax (with uncertainty), interstellar extinction
- Orbital elements (with uncertainties)
- Grade in ORB6 and OARMAC
- Notes in ORB6 and OARMAC
- Indication on spectroscopic and eclipsing binarity

# Some statistics. 1

- The catalogue contains 3139 orbits for 2278 pairs:
  - 1588 pairs have a single orbit,
  - 548 pairs have 2 orbits,
  - 120 pairs have 3 orbits,
  - 19 pairs have 4 orbits,
  - 1 pair have 5 orbits,
  - 2 pairs have 7 orbits.
- Those 2278 pairs combine into
  - 2016 binaries,
  - 76 triples,
  - 26 quadruple systems,
  - 5 quintuple (5) systems,
  - 2 septuple (7) systems

# Some statistics. 2

- For 650 orbits there is no photometry for secondary component
- For 65 orbits there is no spectral type
- Parallax for 270 orbits is unknown, zero or negative

# Step 2:

- Construction of a refined list of PAIRS

# Construction of refined list of pairs

- Remove triple+ systems
- Remove pairs with unknown parallax
- Remove orbits with poor quality (4,5,9 in ORB6, ‘C’ in OARMAC)

- Select one (best) orbit for every pair
  - Compare orbits’ quality
  - Compare dynamical and photometric mass

# Mass calculation

- $M_d = M_1 + M_2 = a^3/(P^2\pi^3)$ – dynamical mass
- $M_{1,2} = f_{MLR}\,[m_{1,2}+5\lg\pi+5-A(l,b,\pi)]$ – photometric mass
- $M_{1,2} = f_{MSR}\,(SpType_{1,2})$ – spectral mass

# Photometric mass estimation: mass-luminosity relation

- Upper MS ($-5<M_V<1.45$): Malkov O. 2007, MNRAS 382, 1073
- Lower MS ($1.45<M_V<17.59$): Henry, T. J., & McCarthy, D. W. Jr. 1993, AJ, 106, 773; Henry, T. J., Franz, O. G., Wasserman, L. H., et al. 1999, ApJ, 512, 864
- Subgiants and early-type (O-F6) giants are 1 mag brighter than dwarfs: Halbwachs J.-L. 1986, AA 168, 161

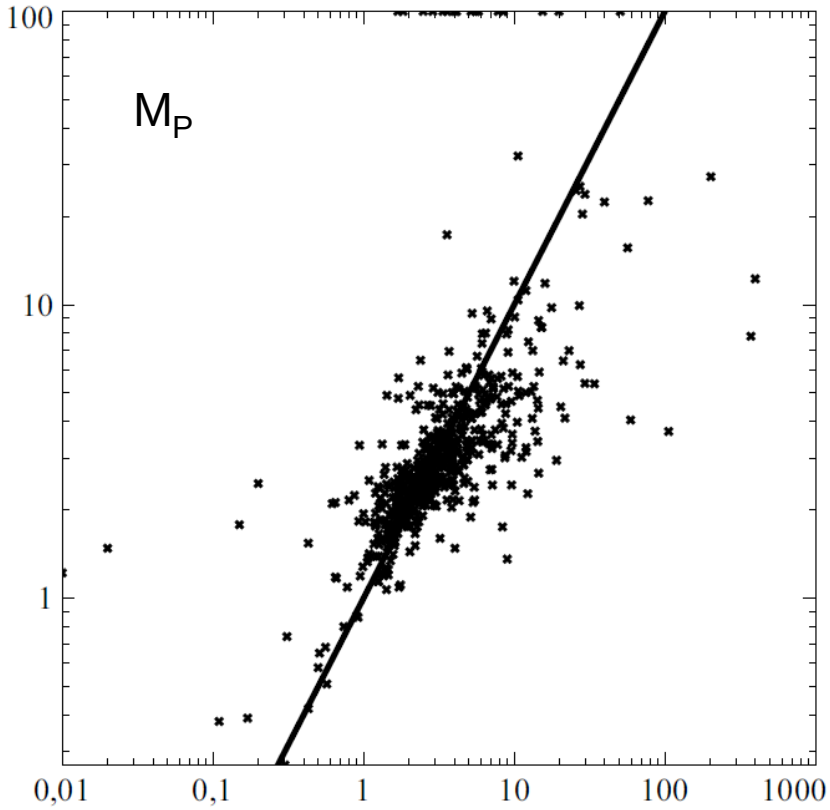
# Dynamical mass uncertainty estimation for OARMAC orbits

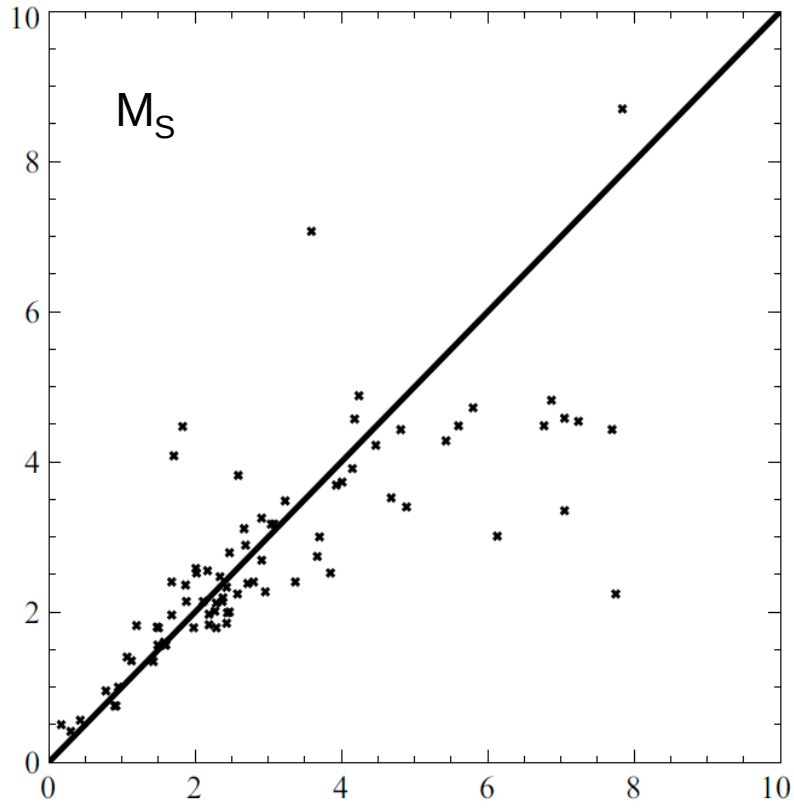
- Errors in P(%): 5, 10, 20 for A,B,C grade, respectively.
- Errors in a(%):  3, 6, 12 for A,B,C grade, respectively.

# Refined list of PAIRS

- 652 orbits = pairs = systems
- Two orbits have dynamical mass < 0.1, four orbits have dynamical mass > 100

# Comparison of dynamical, photometric and spectral mass

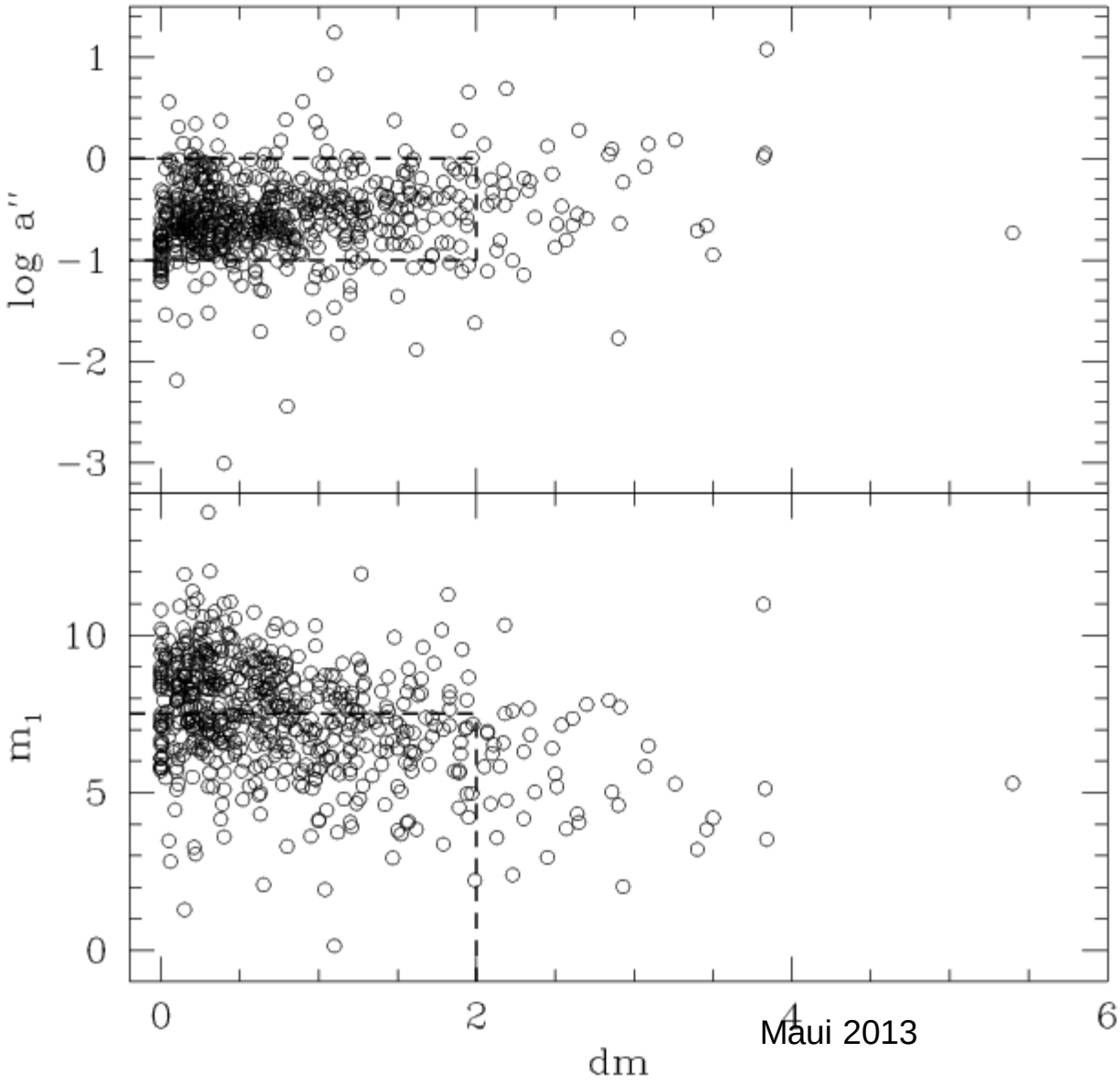


# Possible reasons for discrepancy between dynamical (D), photometric (P) and spectral (S) mass

- Wrong parallax (see parallax value and uncertainty): D, P
- Wrong orbital elements (see orbit's grade): D
- Wrong spectral type (depends on brightness):
  - Spectral (temperature) class: S
  - Luminosity class: P, S
- Third body (see Notes): D
- Unresolved binarity: D, P
- Variability: P, S?
- Interstellar extinction underestimation (for low galactic latitudes): P

# Selection effects



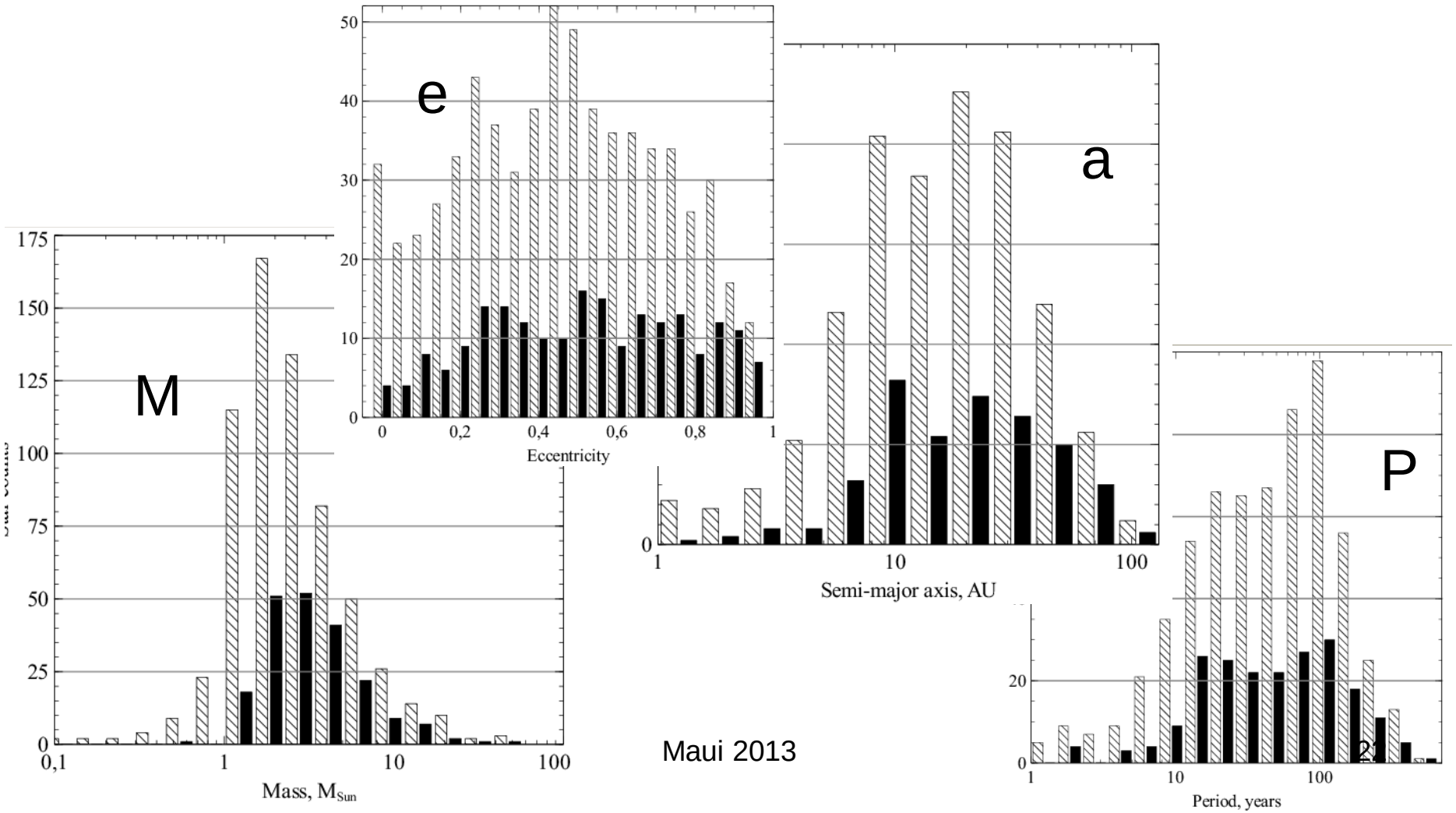

Difference between the magnitudes of the components vs the semi-major axis of the orbit (upper panel) and the magnitudes of the primaries (lower panel).

The dashed lines mark the area that satisfies the definition of selected systems, *a" ~ 0".1 − 1", $m_1 \leq 7.^m5$ and dm ≤ $2^m$.*

Visual magnitudes (V) of components are taken from WDS.

207 systems are selected

# Grey: all 652 systems
# black: selected 207 systems



# Resume

- The resulting distributions are still distorted by the selection effects inherent to the OARMAC and ORB6 catalogues, and cannot be mistaken for initial or present-day distributions of binary parameters.
- They, however, can be used to construct the initial mass function and star formation history of wide binaries. This is a subject for future study.
- Observations to determine spectral types and magnitudes (when absent) are needed.
- The results are published in Malkov et al. 2012, A&A 546, 69; the catalogue is published in VizieR.