Multiplicity of planets hosts

Silvano Desidera
INAF-Osservatorio Astronomico di Padova

Scientific motivations

- **Planet validation**: presence of additional sources within PLATO PSF area may represent source of false alarms
- **Planet parameters**: flux dilution due to additional sources to be taken into account
- **System architecture**: relevance of the presence of stellar companions for planet formation and evolution: statistics of planets in binaries wrt single stars as a function of binary separation, alteration of orbital elements (e.g. Kozai mechanism), circumbinary planets (H. Deeg talk)

Sources of information

- Info available for all sources at PIC level: Gaia DR2 and other all sky catalogs
- Additional info available in literature/archives/prep. obs (before launch)
- Info to be gathered with follow-up observations

Info available for all sources (from Gaia)

Already in Gaia DR2

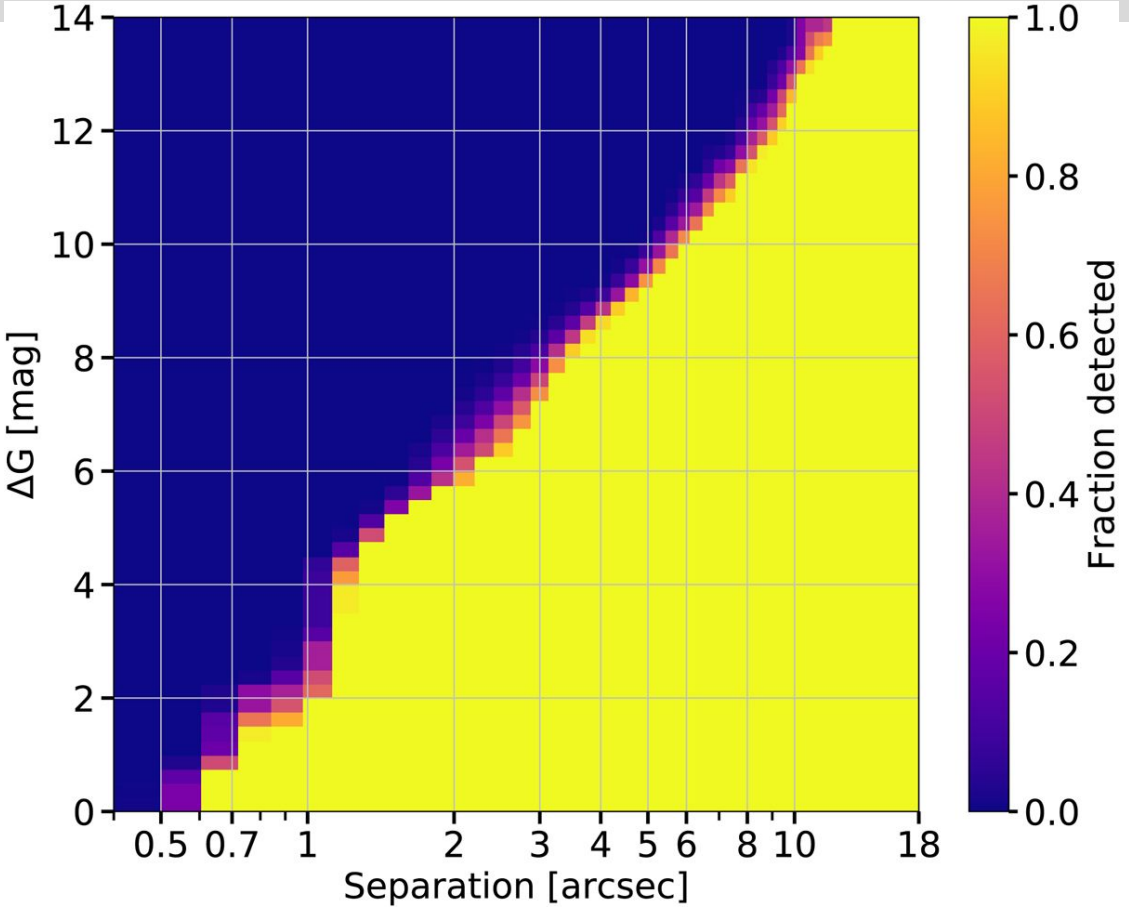
- Visual companions
- Info on physical association (parallax and proper motion): physical companions vs background sources
- Some info on astrometric variability

Future releases (already starting from DR3 for short period and large amplitudes):

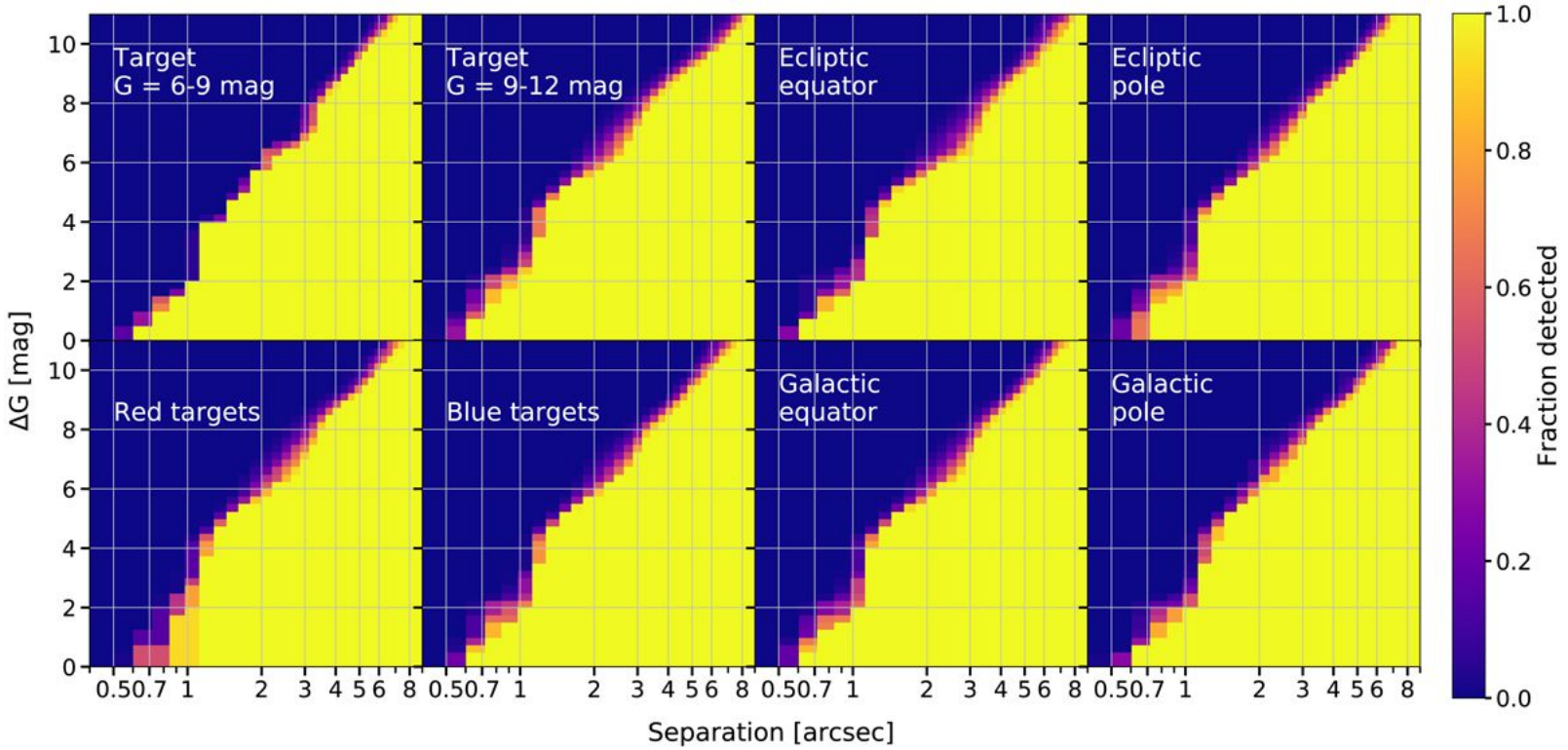
- Astrometric binaries
- Spectroscopic binaries
- Eclipsing binaries

Visual companions

- Typical detectability in Gaia DR2(Brandeker & Cataldi 2019
- Maybe a bit optimistic but some improvements expected in future releases



Visual companions



Implications for PLATO: P1

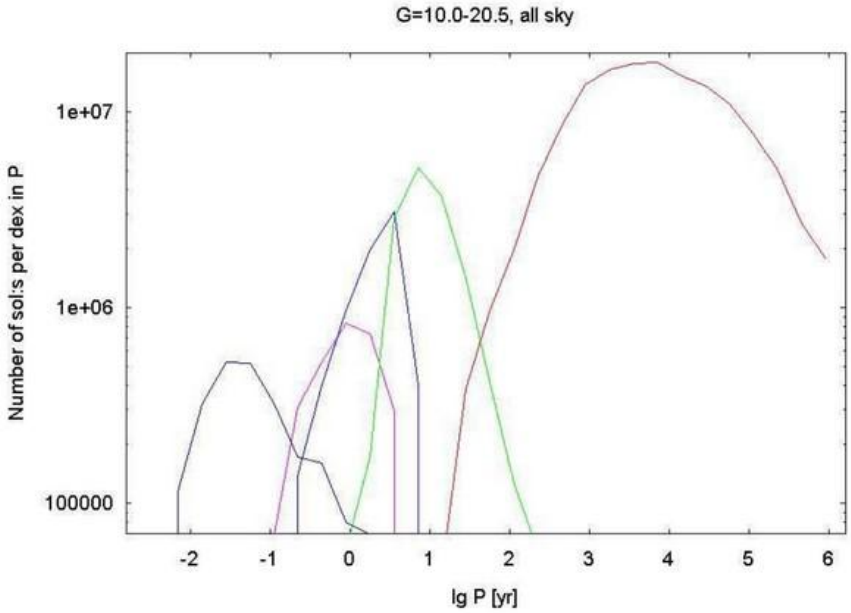
Star	dist (pc) (median value)	mass limit at 1”	physical sep (au)	mass limit at 2”	physical sep (au)	mass limit at 10”	physical sep (au)
F	210	0.82	210	0.46	420	0.082	2100
G	144	0.70	144	0.33	288	0.076	1440
K	67	0.52	82	0.18	134	substellar	670

Implications for PLATO: P5

Star	dist (pc) (median value)	mass limit at 1”	physical sep (au)	mass limit at 2”	physical sep (au)	mass limit at 10”	physical sep (au)
F	549	0.82	549	0.46	1098	0.082	5490
G	389	0.70	389	0.33	778	0.076	3890
K	176	0.52	176	0.18	352	substellar	1760

Other types of binaries

- Old simulations of Gaia outcome for binaries (Soderhjelm 2009)



Estimated numbers of binary solutions from Gaia as a function of period. From left to right: $\sim 7\times10^5$ radial-velocity orbits, 8×10^5 radial-velocity-plus-astrometry orbits, 2×10^6 astrometry orbits, 4×10^6 non-linear proper-motion systems, and 4×10^7 resolved binaries. Gaia will also provide solutions for millions of eclipsing binaries with periods below 10^{-2} yr.

Summary of info from Gaia

- Very useful census of binaries from Gaia (especially for those bright enough to be responsible for the transit signature if EB)
- Could be better quantified through dedicated simulations of PLATO targets (TO BE DONE)
- Significant incompleteness expected at intermediate separation (tens/hundreds AUs for PLATO targets)

Info to be included in PIC

1) existence and main properties of companions (within contaminant table?)
2) possibly physical link (but how to handle ambiguous cases?)
3) spectroscopic, astrometric and photometric orbital solutions (from future Gaia releases)

Additional available information: imaging

- Several large surveys performed/on going with several instruments
- Some efforts in the community for large, homogeneous datasets
  - DIVA database (Vigan+2017) http://cesam.lam.fr/diva/ : collection of detections (companions and background) and detection limits from pre-SPHERE GTO and GPIES published surveys
  - SPHERE Data Center (Delorme+ 2017) https://sphere.osug.fr/spip.php?rubrique16&lang=en on going uniform processing of SPHERE datasets (GTO and open time programs after PI approval)
- Potential for availability of data in the PLATO fields with info on targets observed, detections (physical companions down to planets in outer orbits for young stars and background sources), and detection limits in the regime of significant incompleteness with Gaia

Additional available information: RV

- Several large surveys RV surveys for planets + other for binaries
- Extensive datasets becoming available
  - Keck-HIRES RV survey (Butler et al. 2017)
  - Data products archives: high-quality RV, uniformly processed for HARPS, HARPS-N and other instruments
  - Reduced spectra for other instruments (FEROS, UVES)
  - RAVE and other surveys providing RVs

- Potential for availability of data in the PLATO fields with info on targets observed, detections (down to planets), and detection limits.

Additional available information: photometry

- Several large ground-based surveys covering significant fraction of the sky for variability or planet search + TESS and other space missions
- Data products typically available
- In most cases coarse spatial resolution

Quite complete census of eclipsing binaries on bright targets (much less on faint contaminants)

Summary and conclusion

- Good perspective for census of binaries for all PLATO targets from Gaia
- To be included in PIC
- Additional info for a subset of targets down to planets from imaging and RV available
- Some efforts ongoing for uniform processing and distribution of data products
- Important resources to allow early planet validation/confirmation (several cases for TESS) and to save time for follow-up