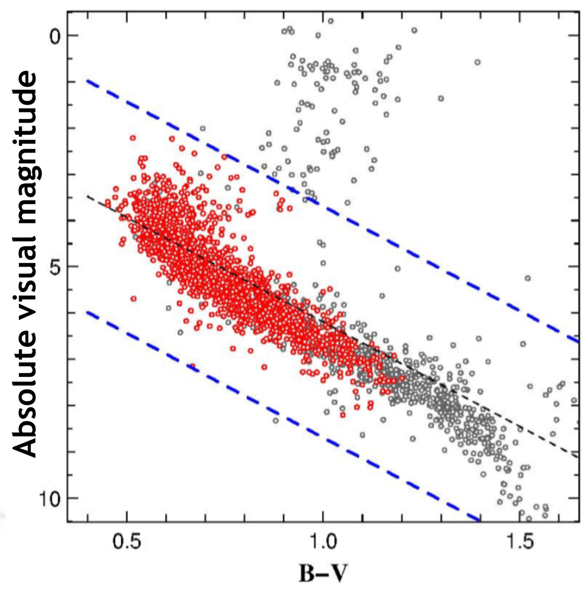
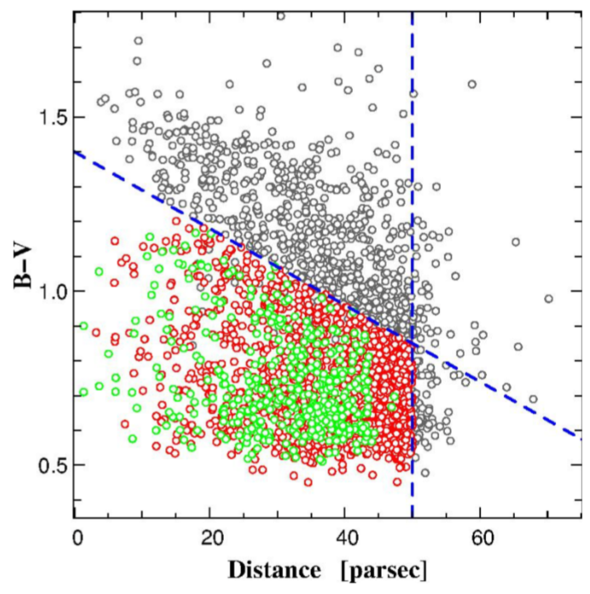
Occurence, mass distribution and orbital properties of giant planets, brown dwarfs and very low mass star companions

Manuela Raimbault manuela.raimbault@unige.ch
PhD student at Department of astronomy, University of Geneva, 51 Chemin des Maillettes 1290 VERSOIX
Damien Ségransan, Maxime Marmier, Stéphane Udry and the CORALIE team

Coralie volume-limited historical sample

The historical CORALIE planet search program is on-going since 1998 and aims at monitoring solar type stars in the southern hemisphere within 50 pc of the Sun [1]. Based on a sample of 1647 F-K dwarfs, the survey is able to detect any companions ranging from low mass stars to giant planets for periods up to 20 years. We present here a first statistical analysis of companions to solar type stars based on the volume-limited CORALIE sample that allow us to update the occurence rate for giant planets [4], brown dwarfs and very low mass star companions. As expected, clear trends and differences emerge in the corresponding mass distributions and orbital elements comparison, which could be compared to formation and evolution models.

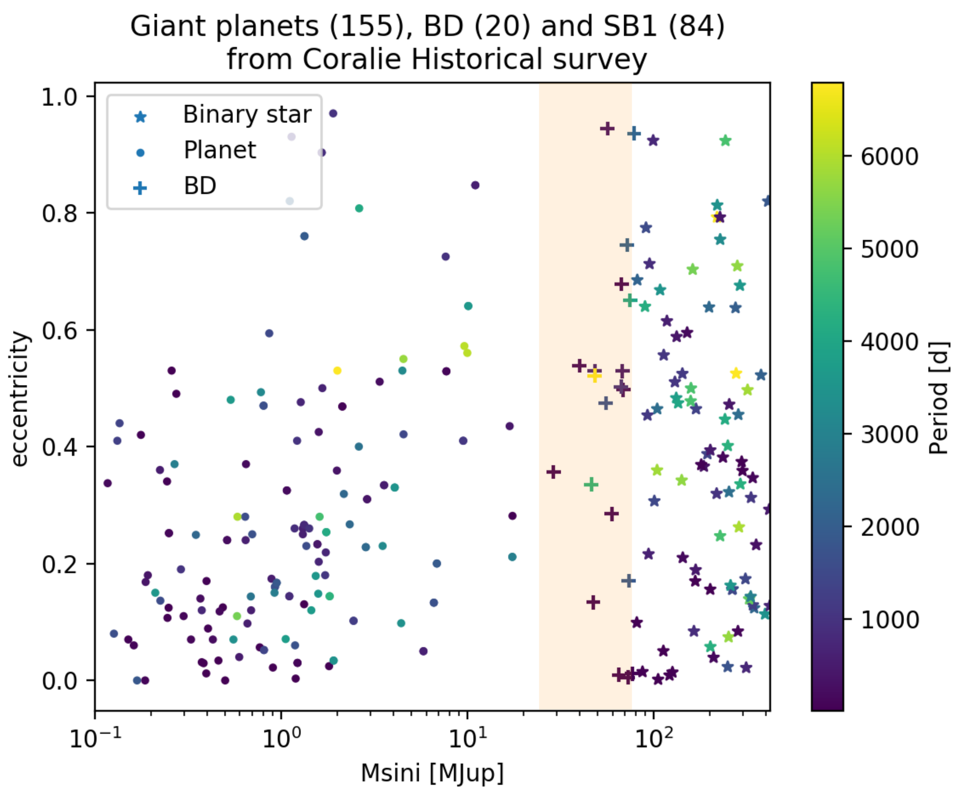


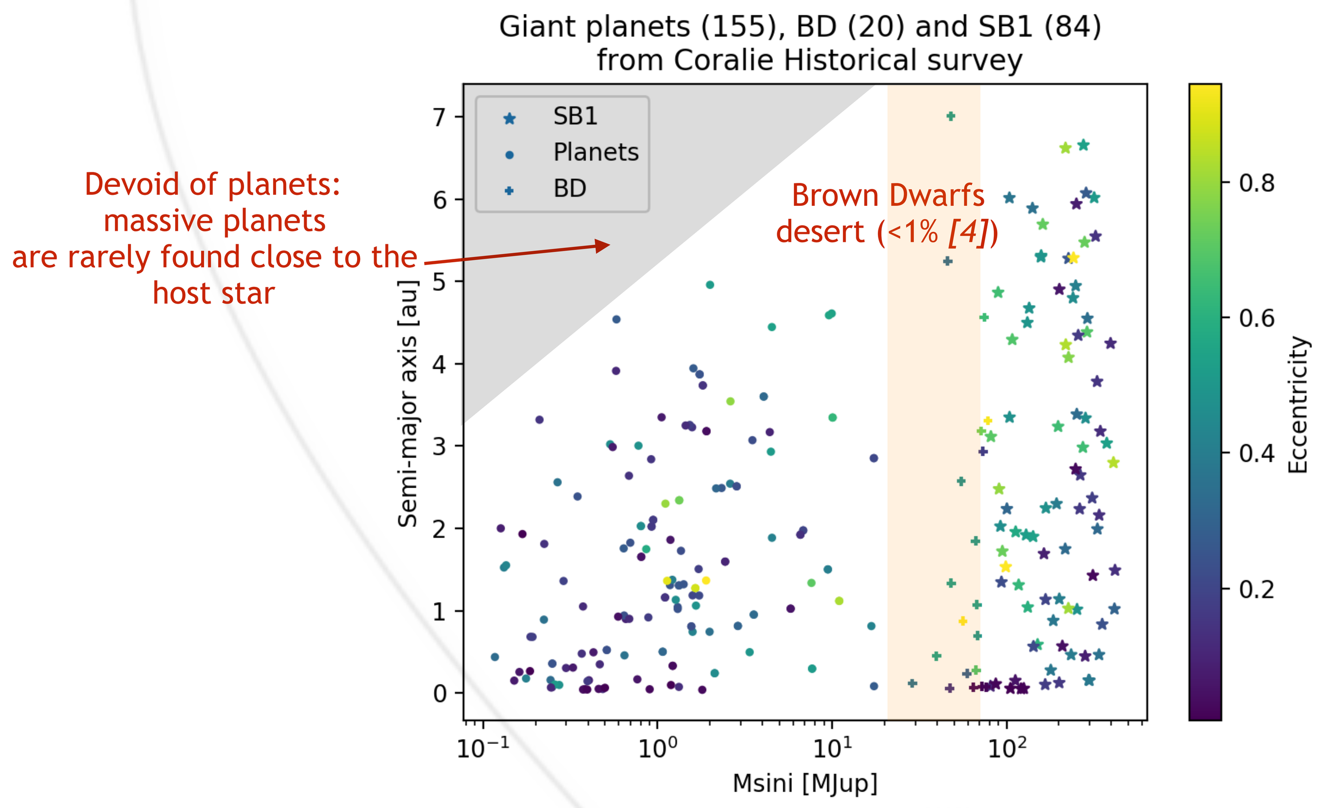


Coralie sample selection (red). Hipparcos targets with spectral types F8 to M0, located within 50 pc, in the southern hemisphere and having a precision σ < 5 mas are shown in grey. Two additional criteria have been used. A photometric limit at 2.5 magnitudes from the Main Sequence (on the left) to eliminate giant stars while a maximum distance as a function of the colour eliminates late type stars having a too low flux (on the right). Targets in green belong also to the HARPS program. [5]

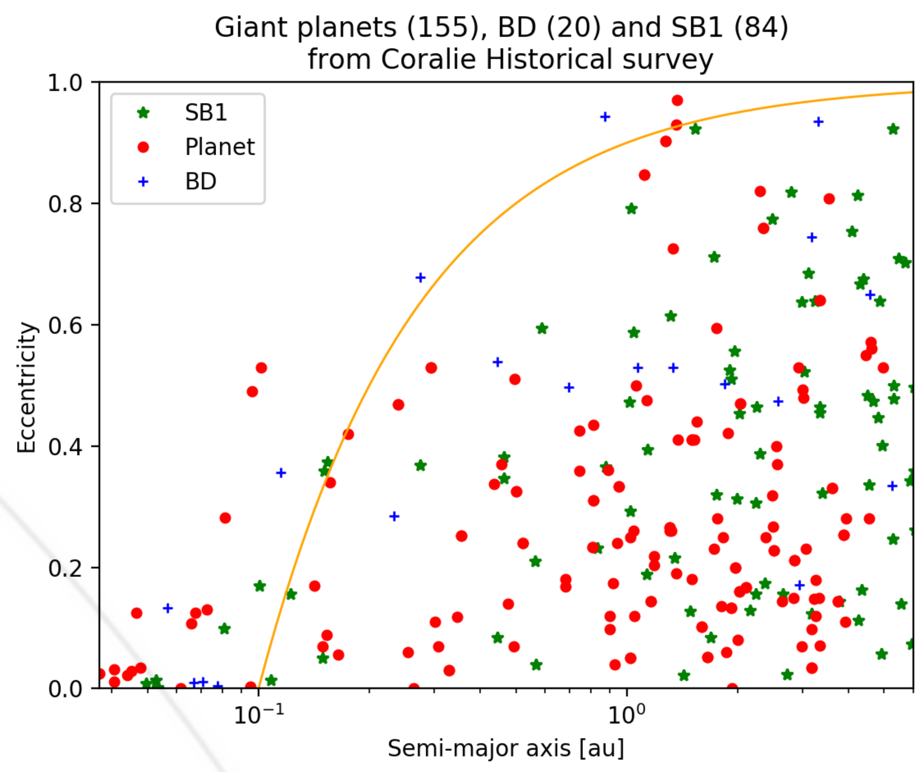
Giant planets, BD and VLMS occurence

As we don't have access yet to the inclination, we are working with Msin(i). All this study focus on stellar companion within 5 AU from its star. We don't correct here for the non-detected companions (Coralie may miss some companions with M < 5 MJup, due to activity or sampling).





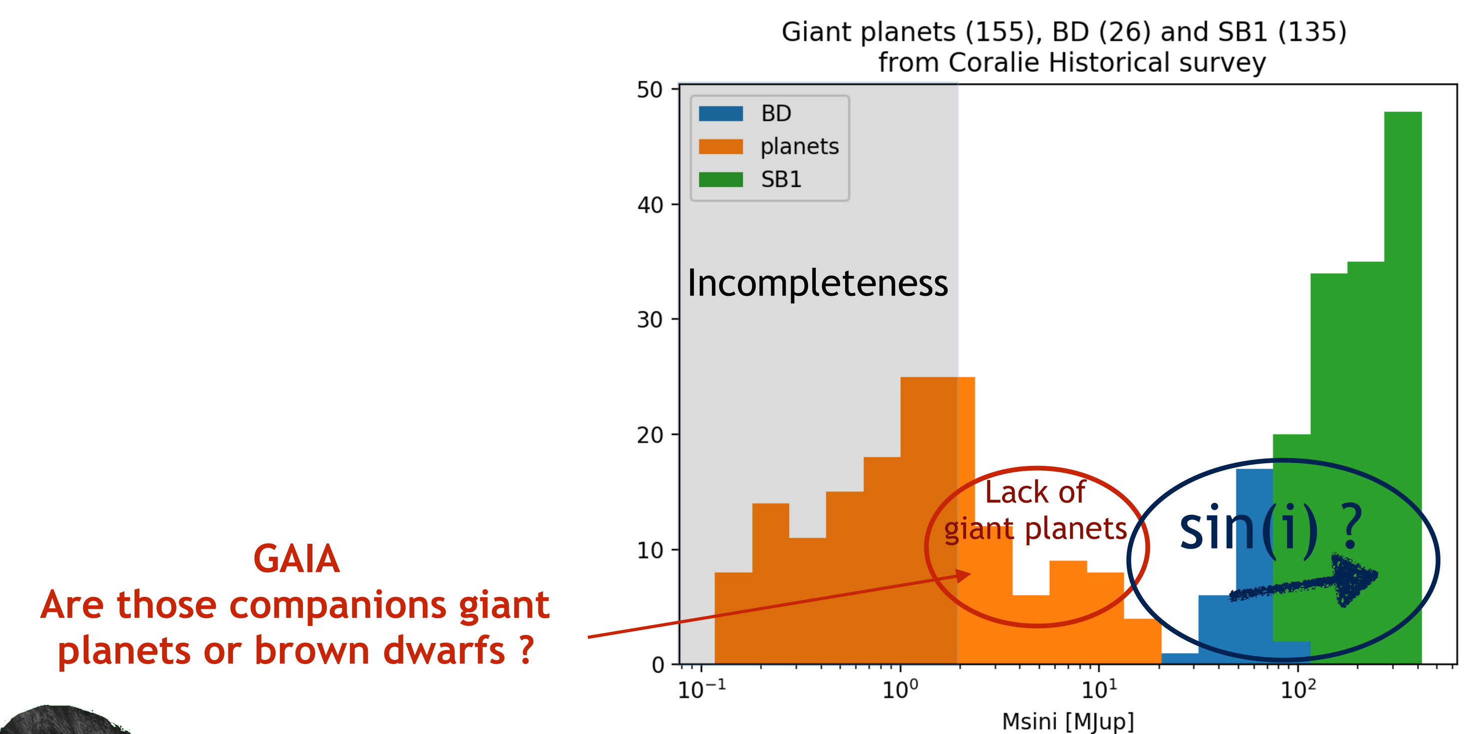
SB1 and BD spread over all the eccentricity range, whereas planets have eccentricities e < 0.6. The few planets having e > 0.6 are indeed orbiting in binary systems. Then, their eccentricities are enhanced by Kozaï effect.



Eccentricities span the full available range, 0.0-1.0, but avoiding those with small periastron distances, r_min = a(1-e) < 0.1 (orange limit), where tidal circularization would occur. A Kolmogorov-Smirnov test returned the p-values listed in the table below. We conclude that we can not exclude the hypothesis that BD and SB1 belong to the same distribution. On the contrary, planets belong to a different distribution, which corroborates the idea that their formation processes are different [2].

	statistic	p-value
Planets - SB1	0.31	6.10^{-4}
Planets - BD	0.47	2.10^{-4}
BD - SB1	0.22	6.10^{-2}

Kolmogorov-Smirnov 2 samples goodness of fit test.

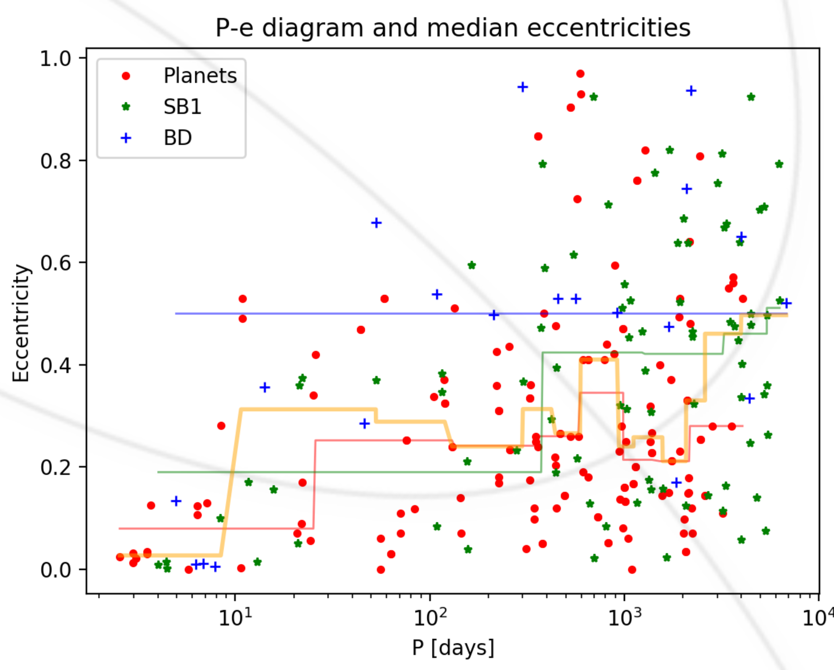


GAIA

> Getting the sin(i)

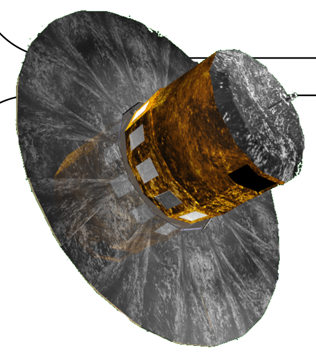
> Do those sources turn out to be VLMS ?

> Astrometry will enable us to determine the true masses [3]



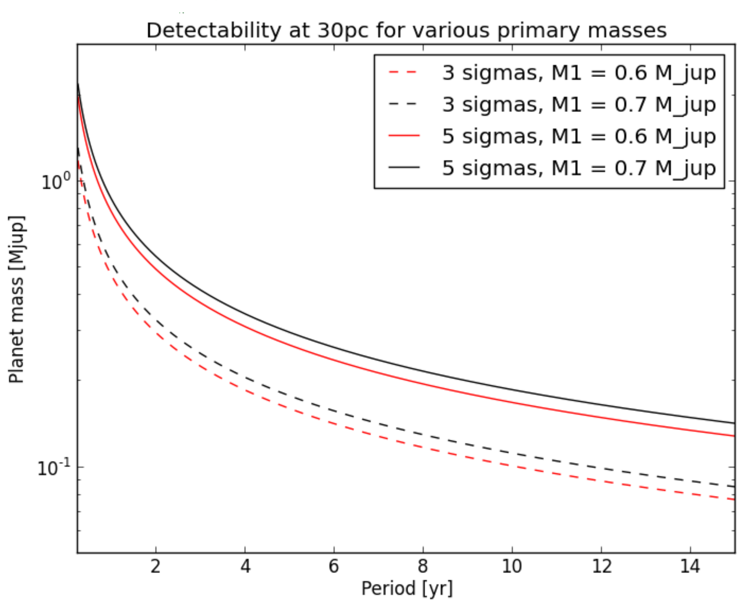
The global median of the eccentricity is shown in orange on bottom figure. Giant planets have a lower eccentricity than BD and SB1.

Perspectives



Correct for non-detected planets (for M < 5 MJup)
Add SB2
GAIA : Architecture and evolution of planetary systems

* Multi-epoch astrometry for nearby stars (500 pc)
* Extends this study to main sequence giants of the close solar neighborhood (0.5 - 5 AU)
* Detection of giant planets:
  * at different ages (different stage of the evolution, from a few Myr to several Gyr)
  * around stars of different masses (0.1 to 5 MSol)
* How do giant planets survive stellar giant and supergiant phases ?
* How dry is the Brown Dwarfs desert ?



By deriving the true masses from GAIA astrometry, we will improve the occurence rate of giant planets, BD and VLMS distribution precision.
This will give us observables that could be confronted to formation and evolution theories of giant planets, but also, of brown dwarfs and multiple stars.

References

[1] Udry et al. 2000, A&A 356, 590–598 (2000) « The CORALIE survey for southern extra-solar planets II. The short-period planetary companions to HD 75289 and HD 130322 »
[2] Halbwachs et al. 2004, in Revista Mexicana de Astronomia y Astrofisica, vol. 27, Vol. 21« Statistical properties of solar-type close binaries »
[3] Sahlmann et al. 2011, A&A 525, A95 (2011) « Search for brown-dwarf companions of stars »
[4] Grether & Lineweaver 2006, ApJ 640,1051 « How Dry is the Brown Dwarf Desert? Quantifying the Relative Number of Planets, Brown Dwarfs, and Stellar Companions around Nearby Sun-like Stars »
[5] Marmier, M. 2014, PhD thesis, Geneva Observatory, University of Geneva.

The National Centres of Competence in Research (NCCR) are a research instrument of the Swiss National Science Foundation