Seven new giant planets in the solar neighborhood

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

Since 1998, a planet-search program around main sequence stars within 50 pc in the southern hemisphere has been carried out with the CORALIE echelle spectrograph at La Silla Observatory [1]. With an observing time span of more than 20 years, the CORALIE survey is now able to unveil Jovian planets on Jupiters period domain. Long-term precise Doppler measurements with the CORALIE echelle spectrograph, together with a few additional observations made with the HARPS spectrograph on the ESO 3.6 m telescope, reveal radial velocity signatures of massive planetary companions on long-period orbits. We spotted 7 new planets whose periods range from 83 to 4468 days. These discoveries help build a better statistical sample and will allow to derive the occurence of giant planets beyond the ice line, which will bring new constraints on formation and migration scenarii. Such systems are also being observed by GAIA since mid-2014, which will allow, in the coming years, to derive the true mass of the planets and reveal the nature of the most massive giant planets.

Radial velocities show a giant planet population in Msin(i)

In addition to a large sample of small planets, radial velocity observations have unveiled massive giant planets (up to 25 MJup), as shown on Fig. 2. This techniques leads to a minimum mass because of the sin(i) degeneracy. Thus, those sources might appear to be brown dwarfs. This uncertainty will be resolved by GAIA astrometry, which will give the true masses. Then, if those companions turn out to be brown dwarfs, their formation process might be well explained by the usual star formation gravitational collapse. However, if the inclination are not so important, those companions will really be giant planets. Then, the most classical model for planet formation i.e. core accretion model, which is efficient for explaining the formation of Jupiter size planets would fail to reproduce those giant planets, while the disk instability would succeed, provided that the disk is cool and massive enough. GAIA will easily provide us with a true masses distribution, since it will be very sensitive in the range of masses M > 2 MJup and separation within 5 AU.

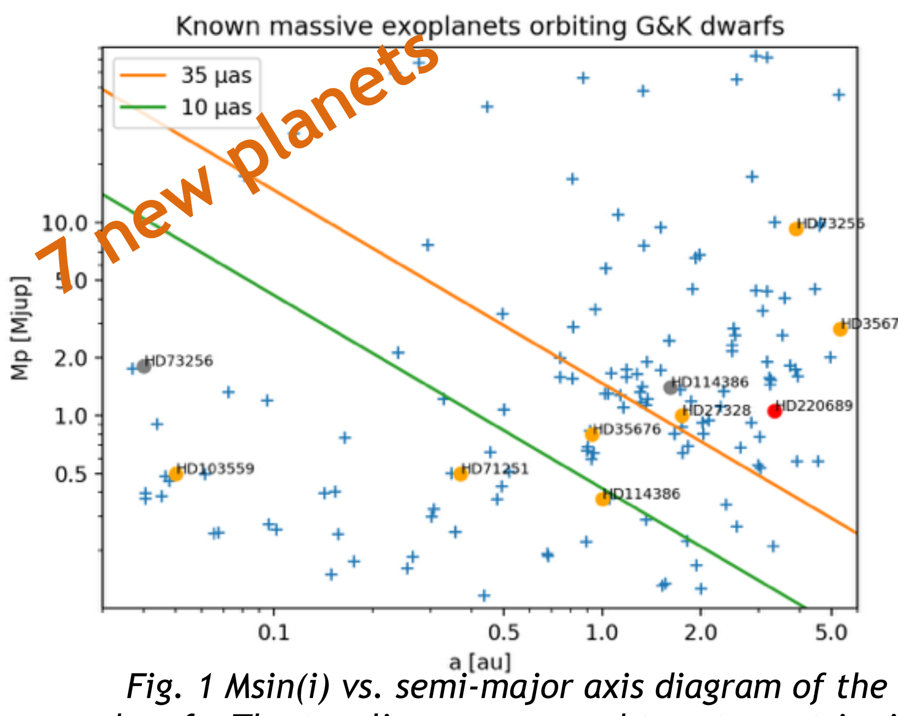
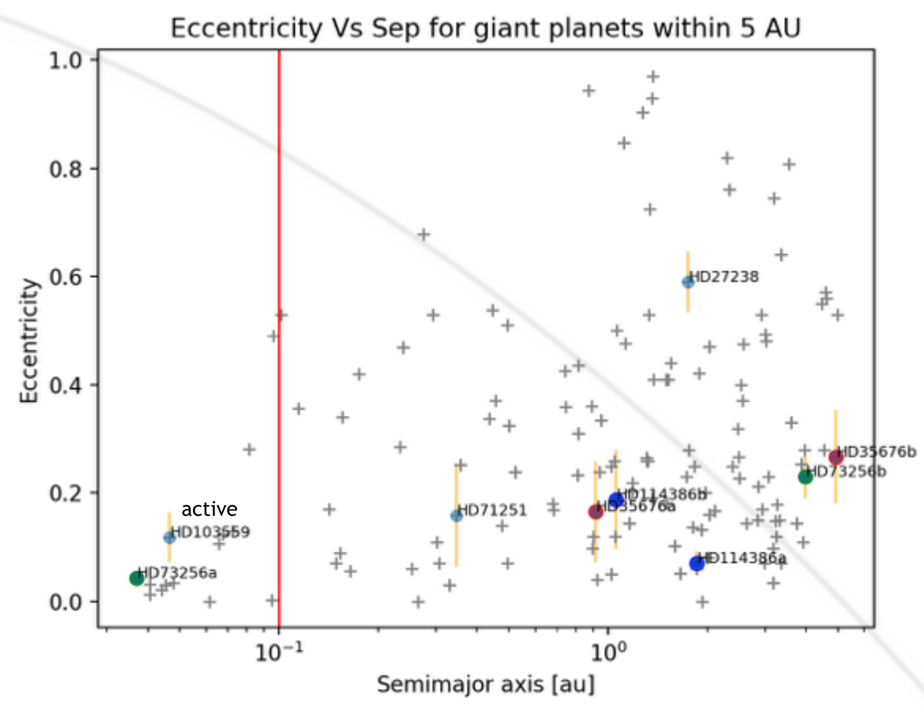


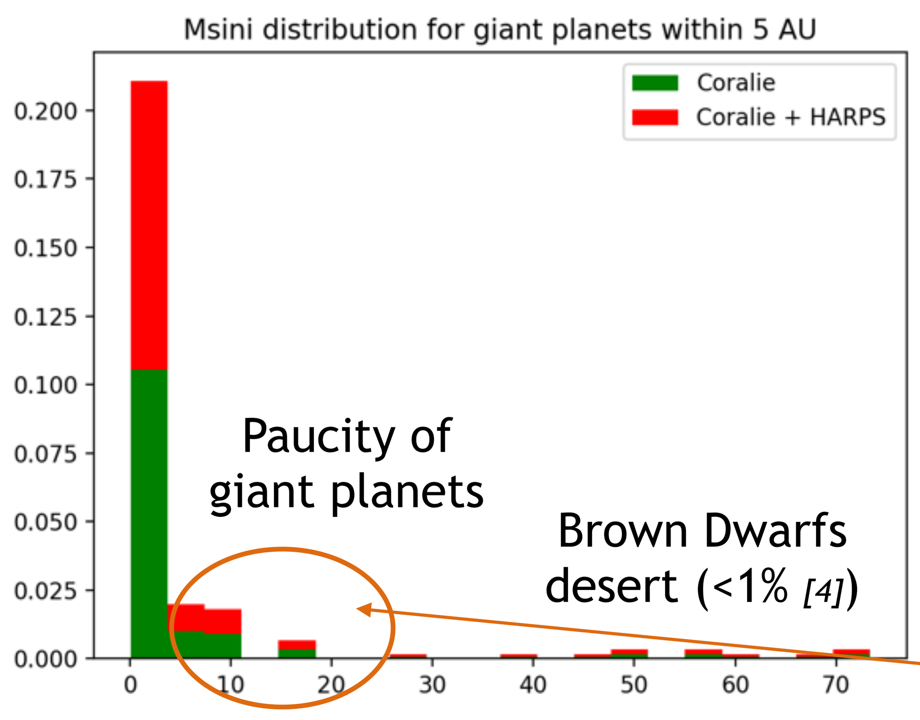
Fig. 1 Msin(i) vs. semi-major axis diagram of the CORALIE sample massive exoplanets orbiting G & K dwarfs. The two lines correspond to astrometric signatures of 7 µas (green) and 50 µas (orange) for a 1 M⊙ parent star located at 40 pc.

* 155 giant planets (among which 7 new planets) within the Coralie sample, detected by several groups.
* GAIA independent detection at 5σ (7 μas precision): 94 sources
* GAIA and RVs combination (factor 3, 10 μas precision): 119 sources



In the litterature (i.e. Halbwachs [3]), planets within 0.1 AU are nearly always on nearly circular orbits, presumably due to tidal circularization. Here, even if a trend appears, it is not that obvious. Beyond 1 AU, the eccentricities distribution is quite uniform.

Note that Coralie sample focuses on late stars, avoids active stars and that distributions are not unbiased of no detected planets, and that HARPS doesn't follow all Coralie sources.



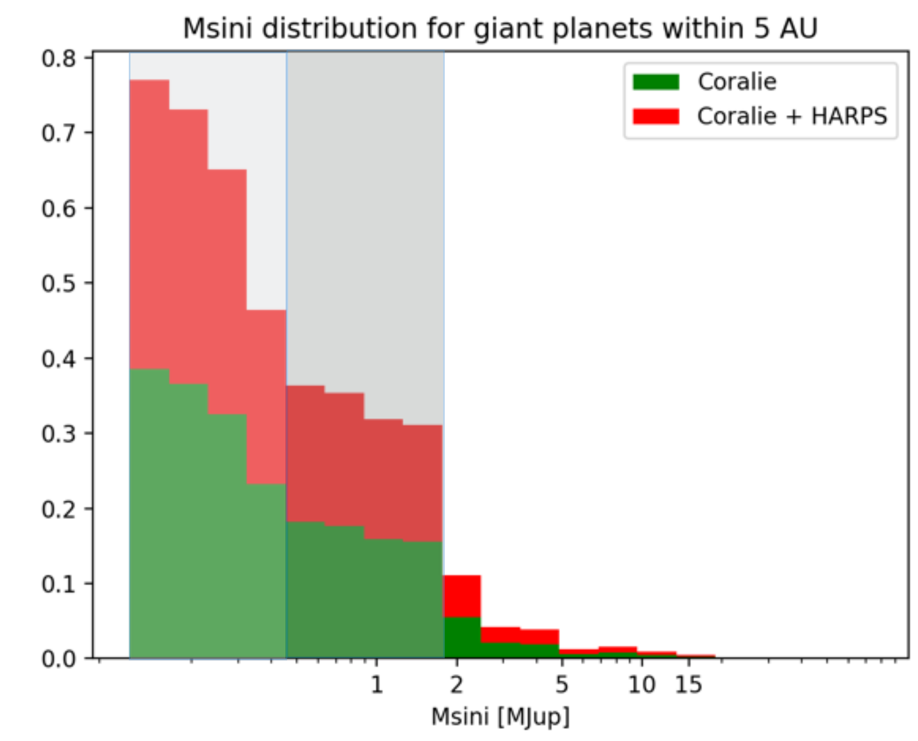


Fig. 3 a) Mass distribution for the 82 Coralie and 73 HARPS giant planets and 9 Brown Dwarfs within 5 AU, for planets more massive than 0.1 Jupiter mass.
b) Log scale.
Coralie is not complete below 1 MJup, so we complete with HARPS data.

How do giant massive planets form ?

By determining the masses of potential brown-dwarf companions, Sahlmann [2] improved our knowledge of the companion mass-function.

RV orbital solutions + Hipparcos astrometry → Orbit inclination → True masses → Brown Dwarfs candidates —msin(i)>25MJup→ Stellar companions

Affected by the Hipparcos astrometric precision and mission duration, which limits the minimum detectable companion mass, and some of the remaining candidates are probably brown-dwarf companions.
Here, we present long period giant planets, which extend this work to the planetary range, where GAIA will bring new astrometric data.

GAIA
Are those companions giant planet or brown dwarfs ?

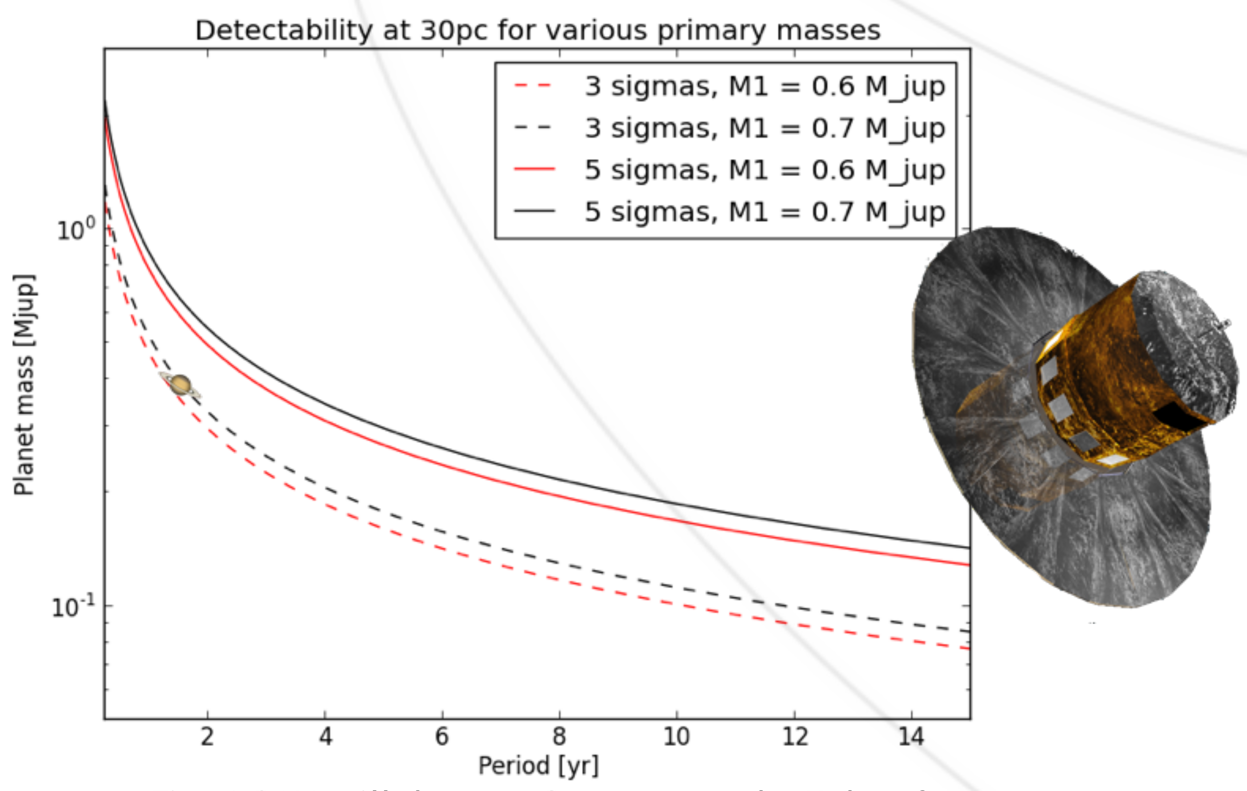


Fig. 4 GAIA will detect a Saturn around a K dwarf.
24 µas @ V=15 for G stars, 9 µas for M stars.

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)
    * around stars of different masses
* How do giant planets survive stellar giant and supergiant phases ?
* How dry is the Brown Dwarfs desert ? (Grether [4])

Perspectives

Derive the true masses from GAIA astrometry, which will improve the mass distribution precision.
This will give us better tools to try to understand the different processes of formation of giant planets, but also, brown dwarfs and binaries.

Build a common distribution of stellar companions including giant planets, brown dwarfs and very low mass stars, in order to constrain planetary formation models.

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] Sahlmann et al. 2011, A&A 525, A95 (2011) « Search for brown-dwarf companions of stars »
[3] Halbwachs et al. 2005, A&A 431, 1129-1137 (2005) « Statistical properties of exoplanets. IV. The period-eccentricity relations of exoplanets and of binary 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 »

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