The close-in super-Earth HD 164922 d discovered by GAPS with HARPS-N@TNG

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Global Architecture of Planetary Systems

Observations of exoplanetary systems show a wide variety of architectures. Determining the rate of occurrence of Solar System analogs (inner terrestrial planets and outer gas giants) is still an open question and it is one of the objectives of the **GAPS** program.

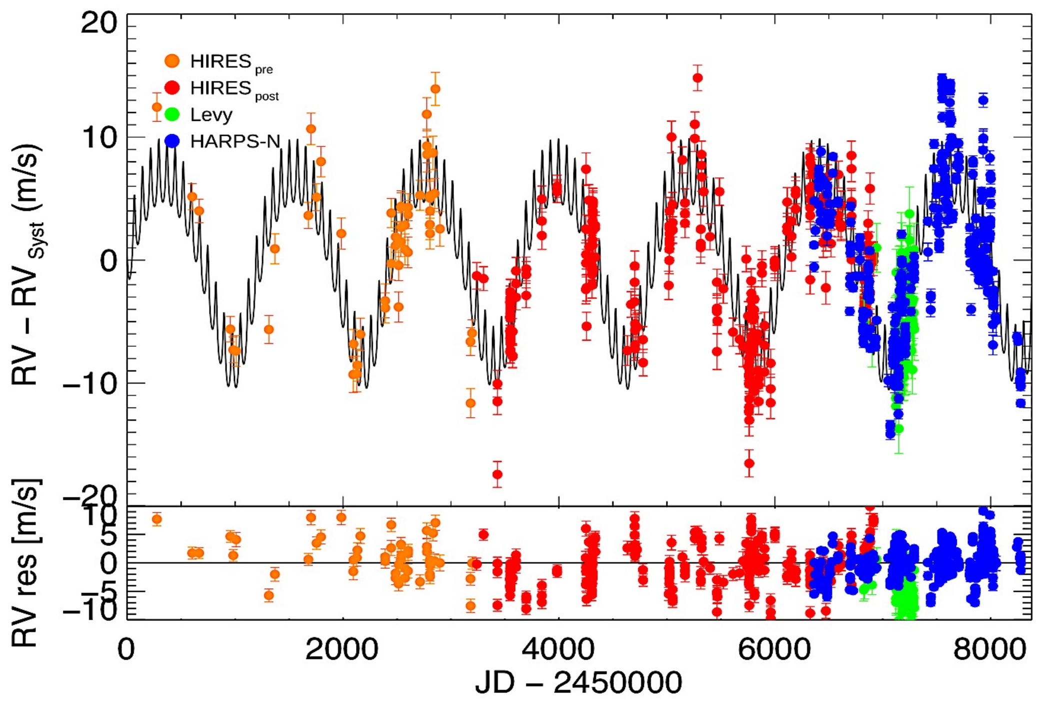
GAPS is an **Italian collaboration** for the radial velocity (RV) search and characterization of exoplanets, with **HARPS-N@TNG.**

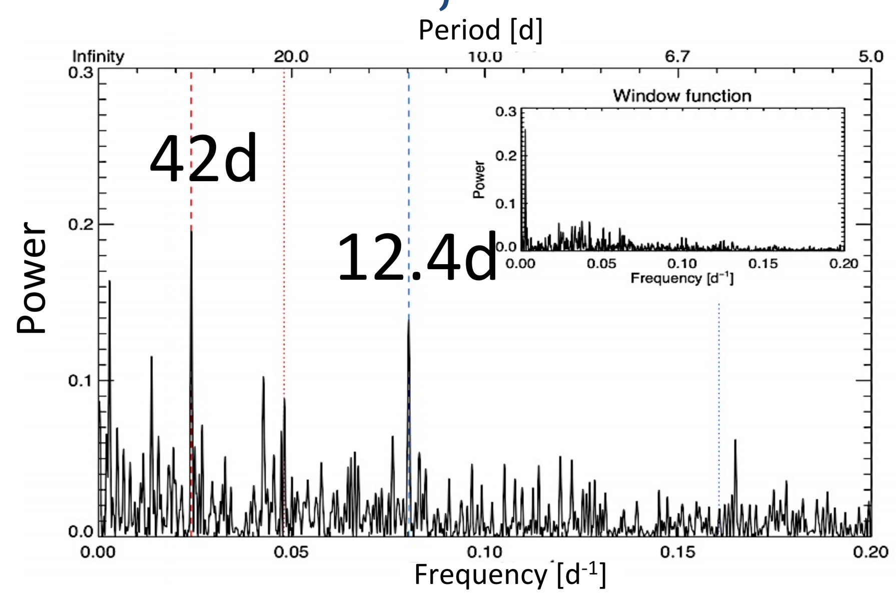
The known planetary system around HD 164922

The bright G9V star HD164922 hosts a gas giant planet[1] in a wide orbit (P_b~ 1200 d, a_b~ 2 au) and a Neptune-mass planet[2] (P_c ~ 76 d).

We investigated the presence of **additional low-mass companions** in the inner region of the system with a **high-cadence monitoring**.

The GLS[5] of the two-planet fit shows periodicities at 42 and 12.4 days.



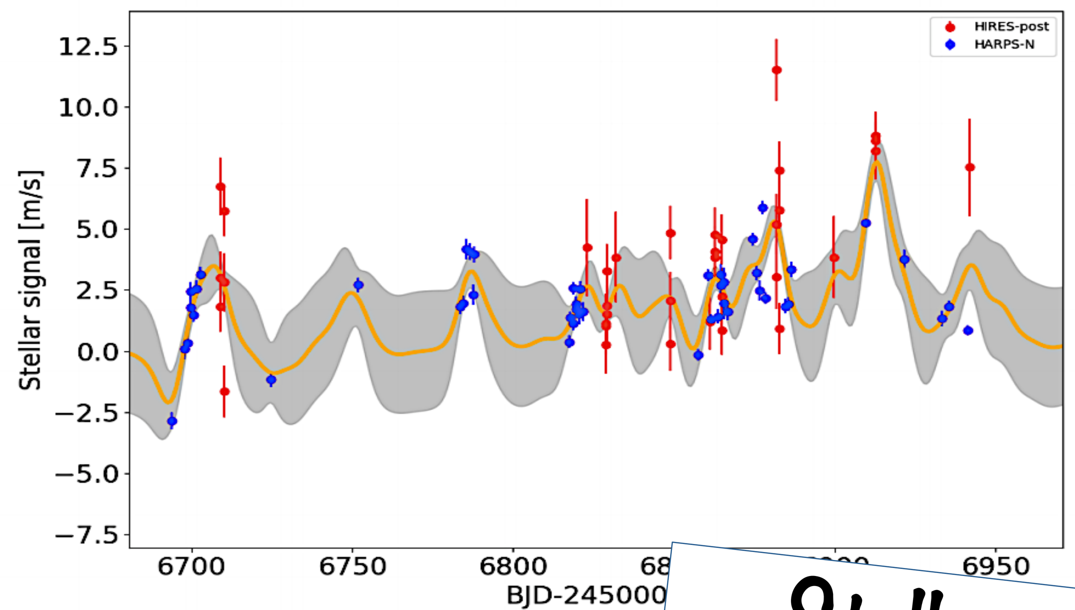


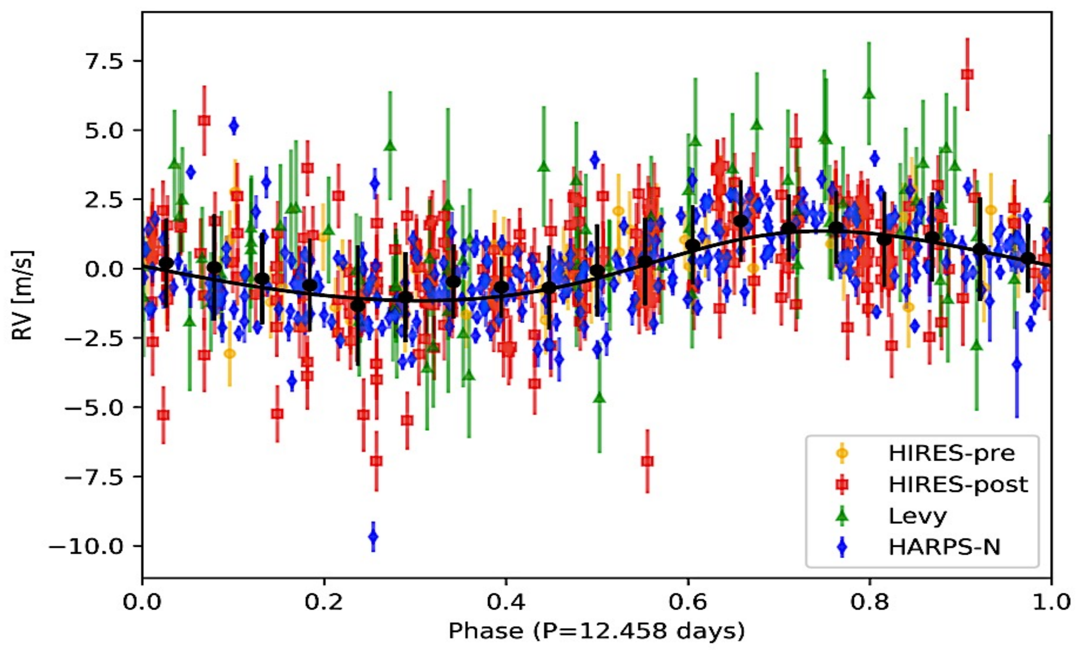
Left: Full RV set from [2], [3] and HARPS-N data. ***Below:*** GLS of the residuals

Radial Velocity analysis

A three-planet fit, obtained from a Gaussian process (GP) regression of the whole RV sample (684 data spanning 22 yrs), confirmed that the periodicity at **12.46 d** is the signature of a **new planet in the system**, a super-Earth with RV semi-amplitude of just **1.3 m/s** ($m_d$sini = 4 M_E). The orbital eccentricities resulted to be consistent with zero for the three planets.

GP modelling of the RV stellar contribution





Above: *Full RV dataset phased at the orbital period of the newly discovered planet.*
Right: *Updated parameters of the system*

Parameter	Value
K_b [m/s]	6.7±0.3
P_b [d]	1207±4.5
$m_b$sini [M_E]	116±11
K_c [m/s]	2.2±0.2
P_c [d]	75.74±0.06
$m_b$sini [M_E]	13±3
K_d [m/s]	1.3±0.2
P_d [d]	12.458±0.003
$m_b$sini [M_E]	4±1

Stellar Activity

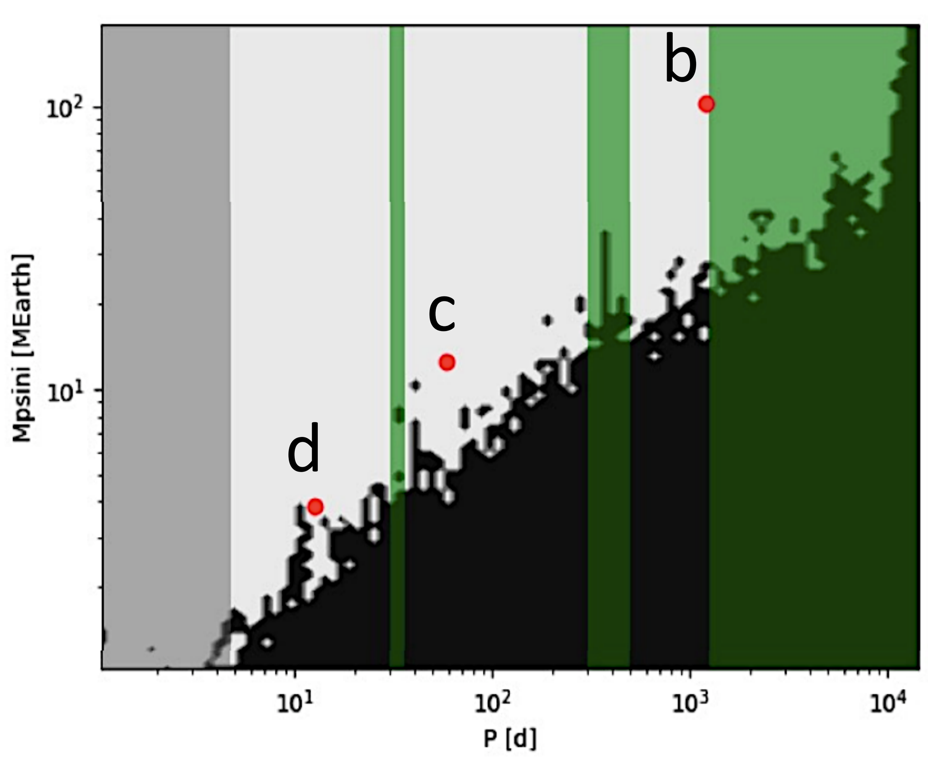
The **GLS** of the **activity indicators**[6,7,8] shows no significant power at 12.4 and 42 d. The latter should be the stellar **rotation period** according to the value of the logR'$_{HK}$ index [9,10].

A **GP regression** of **logR'$_{HK}$**, revealed a periodicity of **42.3 d**, as expected.

The application of the **Kernel regression** technique[8] to the three-planet fit residuals, shows that they can be described as a function of time and activity indices.

System characterization

- ✓ We verified the long-term orbital **stability** with a dynamical analysis and located the allowed regions for additional planets.
- ✓ The planetary orbital parameters and the location of the snow line (1.3 au) suggest that this system has been shaped by a **gas migration** process that halted after its dissipation.



Detection limits for additional planets in the identified allowed regions (green areas).

Conclusions

One of the richest RV datasets allowed to the GAPS team to detect a third inner planet in the system of HD164922. The high-precision of HARPS-N (~0.4 m/s) has been crucial in this finding, together with a high cadence data sampling and the exploitation of the GP regression technique.

References

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