Confirming emerging rocky planets

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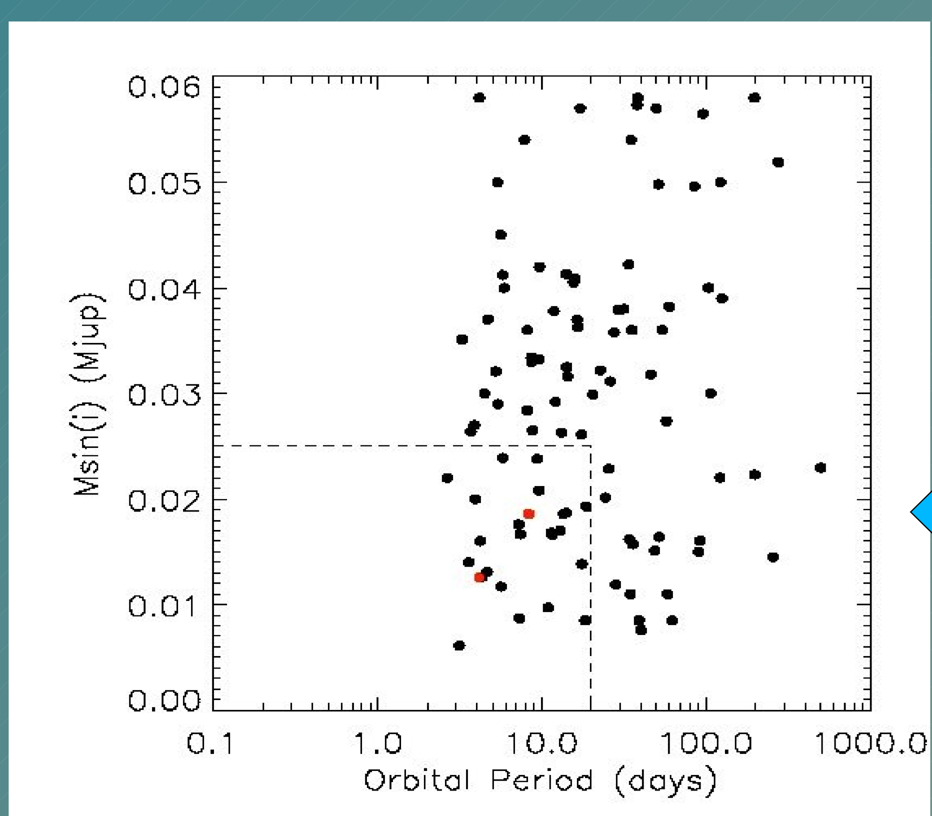
Abstract:

We selected 68 targets that present rocky planet candidates with short orbital periods in the long running Keck Planet Search Project (e.g., Vogt et al. 2010, ApJ, 708, 1366). These targets presented putative signals in the 1-2.5 m/s amplitude range, in hundreds of radial velocity data points obtained with Keck/HIRES, but they are just below the Keck's detection limit. We are using the precision of HARPS-N spectrograph to compliment the Keck data to efficiently detect low-mass rocky planets.

The project expects to increase by more than 50% the actual number of exoplanets in the short period sub-Neptune mass planets (see Figure 1). The extension of the actual list of low-mass rocky planets will contribute to discern the physics of rocky planet formation and evolution.

Sample characteristics:

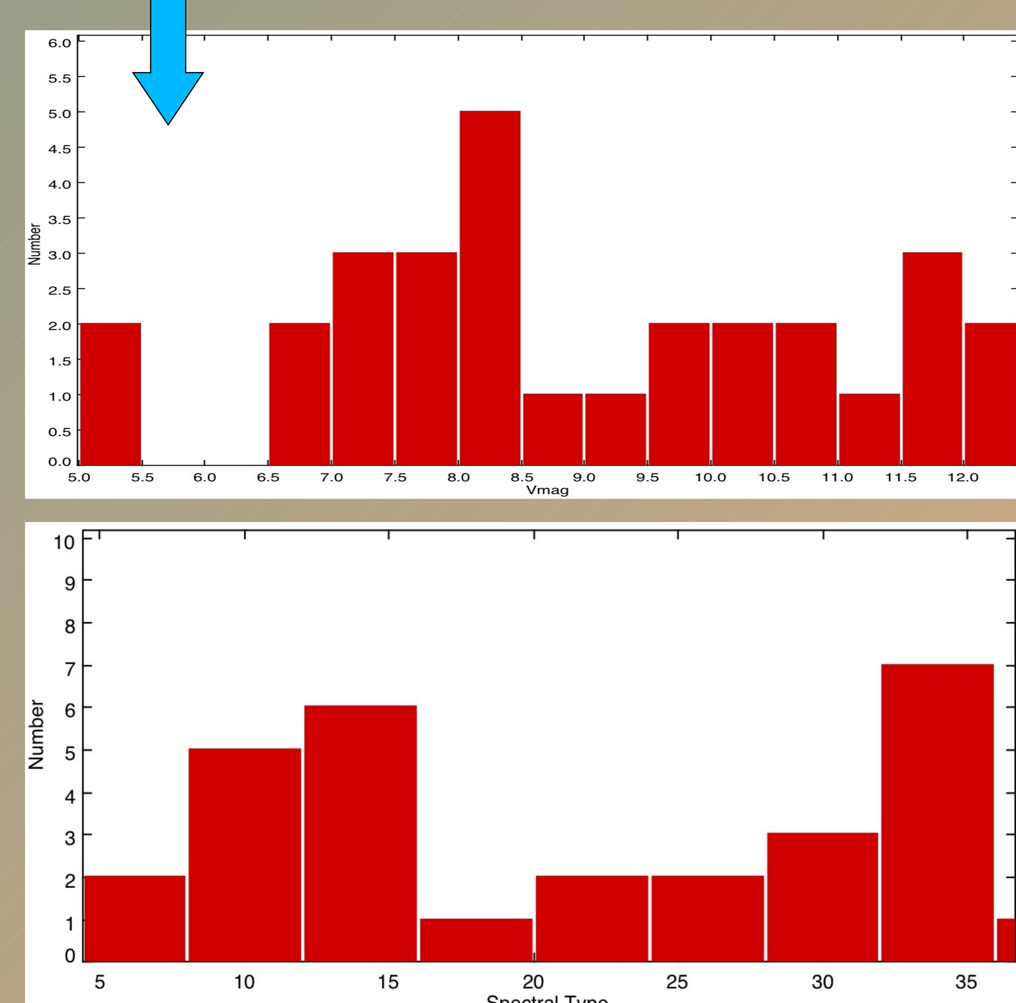


The host candidates are nearby bright stars (V<10) that are inactive (log RHK< -5.0) and that have exhibited no significant radial velocity variations over the course of ~10-17 years monitoring.

Their spectral types range from F5 to M6, and following preliminary orbital fitting results we will find exoplanet within 4-10 days period range and Neptunian masses.

Figure 1 The period and mass distribution of all sub-Neptune mass planets currently detected by radial velocity programs, black dots. The dashed box represents the region of parameter space we intent to populate with this project. Red dots show the results of two of our candidate list.

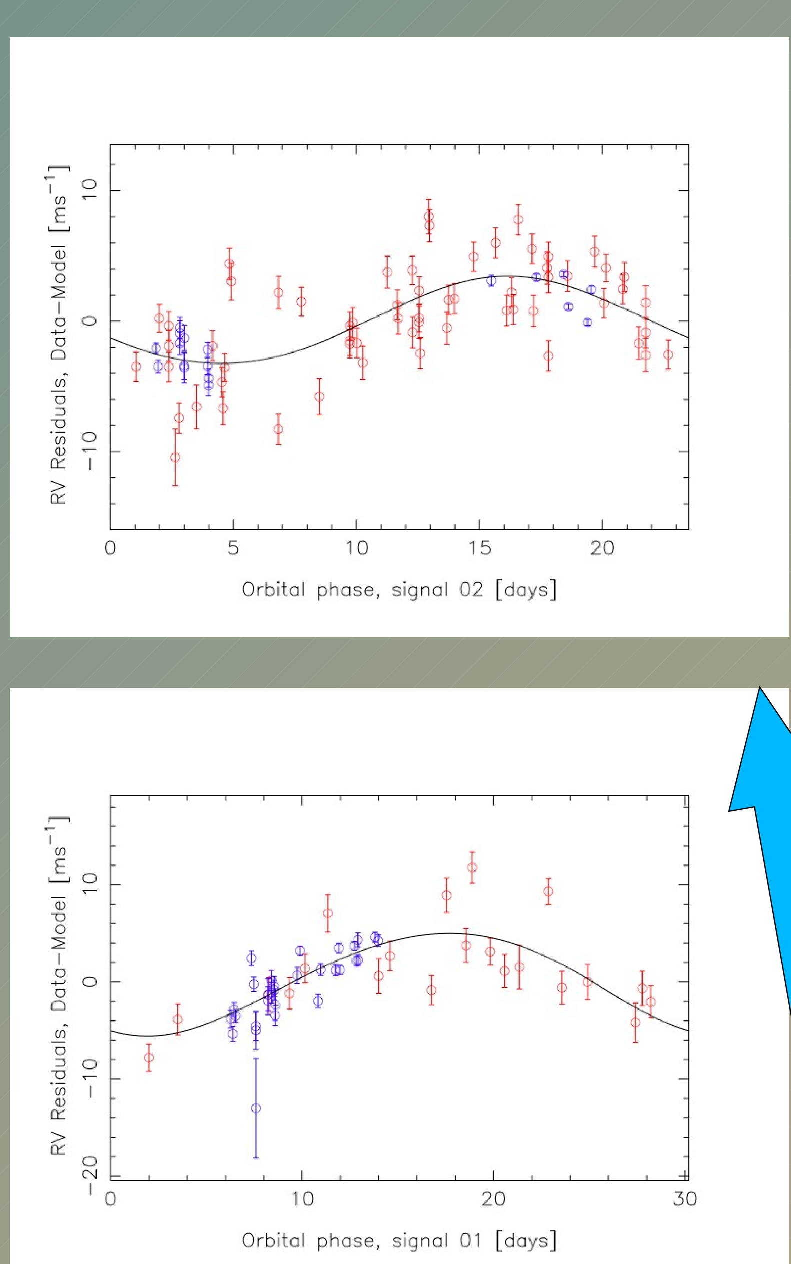
Figure 2 Sample distribution for stellar V magnitude and spectral types, were F5=5, G0=10, G5=15, K0=20, K5=25, M0=30, M5=35.



Observations:

A total of 389 spectra of 28 different targets were taken during 4 observing runs between 2012 and 2014 with the HARPS-North (High Accuracy Radial velocity Planet Searcher) echelle spectrograph. HARPS-N is fibre-fed by the Nasmyth B Focus of the 3.58 m Telescopio Nazionale Galileo (TNG) at Observatorio del Roque de los Muchachos (La Palma, Spain). With a 4k4 E2V chips CCD and 15 µm of pixel size, it covers the wavelength range between 3830 to 6930 Å in 68 orders, with a spectral resolution R=115000.

HARPS-N pipeline supplies science quality extracted spectra through standard process: localization of the spectral orders on the 2D-images, optimal order extraction, cosmic-ray rejection, wavelength calibration, and corrections of flat-field (Cosentino et al. 2012, Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, 8446).



Data analysis and Orbital solutions:

The radial velocity measurements and its corresponding errors are obtained through the HARPS-N on-line pipeline, based on the numerical cross-correlation function (CCF) method (Baranne et al. 1996, A&AS, 119, 373) with the weighted and cleaned-mask modification (Pepe et al. 2002, The Messenger, 110, 8), by utilising the mask that best matches the spectral type of the star from the list of available masks (G2, K0, K5, M0). It also provides measurements of the asymmetry of the mean-line profile, bisector span and full-width-at-half-maximum of the CCF, that help to discriminate if radial velocity variations are due to activity (spots, ..) or the presence of a companion.

We also make used of the least-squares template matching approach implemented by HARPS-TERRA software (Anglada-Escudé & Butler 2012, ApJS, 200, 15).

Confirmation of radial velocity variation nature and orbital solution were obtained using the Bayesian criteria described in Tuomi et al. (2014, MNRAS, 441, 1545), using posterior samplings and model probabilities.

Figure 2: Two examples of phased plots from combining Keck and HARPS-N data. Red points are Keck, blue are HARPS-N. These represent (some of the) examples where pre-existing periods have been confirmed by HARPS-N observations.

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