

Best methods to mitigate stellar radial-velocity signals in the quest for other Earths

Short introduction

After the detection of a large number of the known exoplanets, the radial-velocity (RV) technique is now starting to be limited by intrinsic stellar signals. This is because we are looking for smaller and smaller planets, which induce RV variations on their host stars of just a few meters per second. Our best spectrographs are now reaching precisions at which the effects induced by stellar pressure waves, convection, surface activity and magnetic cycles are visible. Separating stellar-induced signals from planet-induced signals is challenging. But in the quest for planets like our Earth, orbiting in the habitable zone of close-by stars, it is mandatory that we can separate the two signals and confidently detect the planetary signatures.

Detail of the work planned

A number of teams have recently collaborated on the “RV challenge” (Xavier Dumusque, in prep.) a hare-and-hounds exercise with the objective of finding the optimal way to analyze RV data contaminated by astrophysical signals, to enable the detection of very small amplitude signals caused by orbiting planets. The stellar contaminations are currently the major limitation to measuring the mass of Earth-like planets with precise radial velocities. At present, and in the near future, a tremendous amount of observational effort is dedicated to the search for small planets orbiting far from their host star, possibly in the habitable zone. The goal of the RV challenge was to make sure that the community is prepared and develops the best methods to deal with the stellar contaminations in an optimal way.

The team at Torino, lead by Mario Damasso, has used Gaussian processes together with other techniques, to disentangle stellar and planetary signals. They were hugely successful in recovering planetary signals with amplitudes larger than 1 m/s from amidst the stellar noise. One of the objectives of this visit is to develop further the analysis of the simulated data from the RV challenge. In particular, the method proposed by Faria et al. (2016) will be adapted and tested with these data, and the expertise and methodologies of the Torino team will be combined with the ones currently being developed by the applicant and the team in Porto. Now that all the details of the construction of the simulated data are known, we will work together to understand what is the best way to adapt the current methods to improve the planet detection limits. The insight that we will develop from this exercise will help us in the analysis of real data from current (HARPS, HARPS-N) and future (CARMENES, SPIROU, ESPRESSO) dedicated RV instruments and, we hope, will steer us in the direction of detecting small planets like our own.

Why the host institute

As was mentioned before, Mario Damasso (INAF Torino) lead a team that participated in the RV challenge and achieved very good results in the recovery of the hidden planetary signals. Most of the members of this team are currently working in the host institute and will be available during the visit for discussions and collaboration. Gathering the expertise of these researchers will be extremely important to find the best ways to improve the analysis tools.

The host institute is also part of the GAPS collaboration, a long-term program aiming at characterizing planetary systems as a function of the host star's mass, metallicity and environment. Several researchers (A. Sozzetti, M. Damasso, A. Bonomo) have expertise in high-resolution spectroscopy, stellar activity, planet formation and planetary dynamics. This visit will allow for collaboration regarding the detection and determination of the frequency of low-mass planets as a function of stellar metallicity, a key point in understanding planet formation and evolution.

Potential outcomes

As results of the collaboration and visit we expect to analyse all the simulated data sets that are part of the RV challenge, at the same time as we compare our results to the ones obtained by the other teams. We will prepare a publication describing the new methods we develop, and make publicly available the software that we write for this analysis.