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GAPS: Results from 5 years of observations

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The "Global Architecture of Planetary Systems" (GAPS) Project is the result of a collaboration among part of the Italian exoplanetary community that exploited the great capabilities of the HARPS–N instrument. It gathers more than 60 astronomers from several institutes of the Italian National Institute for Astrophysics (INAF) and Italian Universities (Padova, Torino and Milano). A technical and scientific support is also provided by a few collaborators from European and American Institutions. The main purpose of GAPS is the study and the characterization of the architectural properties of planetary systems through the radial velocity technique, by analyzing the distributions of planetary parameters and their correlations with those of the host star. The opportunity to extend our knowledge of the planetary systems will help to understand the most debated aspects of the exoplanet research, such as their formation and evolution. The GAPS observing programme started in September 2012. Since then $\sim$ 2500 observing hours were allocated and about 7000 spectra have been collected for the targets of our sample ($\sim$ 300 stars). For 16 interesting objects we have obtained 90 or more RV data points. The GAPS observations are performed with HARPS–N, the twin instrument in the northern hemisphere of HARPS at the 3.6m ESO–La Silla telescope. These two spectrographs are fiber–fed and work in the the visible range ($400 - 600$ nm) with a resolution of 114,000. They represent the state of the art for the measure of high precision radial velocities: thanks to the simultaneous calibration technique [1] and the extreme instrumental stability, ensured by a series of control systems, they can reach a RV accuracy better than 1 m s^{-1}. In the framework of the GAPS project, HARPS-N spectra are also supported by a coordinated photometric monitoring, in particular for M dwarf stars, performed through the APACHE (Astronomical Observatory of the Autonomous Region of the Aosta Valley, [2]) and EXORAP1 (Serra la Nave Observatory) surveys, from the INAF–Astrophysical Observatory of Asiago and by a number of amateur astronomers. Thanks to the wide expertise of the GAPS members (high-resolution spectroscopy, stellar activity and pulsations, crowded stellar environments, planetary systems formation, planetary dynamics, data handling) our data are carefully analyzed and discussed within the community, aiming to produce scientific results with a quality as high as possible.

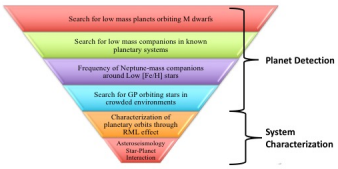

Figure 1: The scientific objectives and the six sub–programs of GAPS subdivided in the two main branches, planet detection and system characterization

We have developed robust RV data analysis tools (DE-MCMC, Gaussian processes) which are in use to analyze RV data affected by astrophysical noise and to enable the detection of very small amplitude planetary signals. These tools showed their effectiveness also in the international context, as in the "RV challenge" experiment (see [3]) and in the collaboration with the HARPS-N GTO program, allowing a preliminary mass estimate for the first transiting habitable-

zone Super-Earth (in a multiple system) around the M0 dwarf K2-3 [4]. The scientific objectives of GAPS, which are pursued by six sub-programs focused on different type of stars, can be separated into two main aspects: planet discovery and planet characterization (see Fig. 1). Several interesting results were published up to now and even more papers are in preparation or close to the submission. A number of planet candidates has been identified but in some cases we need more data for their confirmation, so we plan further observations. After five years of HARPS-N observations and analysis we have developed an optimized observing strategy and new analysis tools, in particular for those objects which require many data and specific treatment of the RV time series. Anyway, new perspectives are foreseen for GAPS, since GIARPS is now available at TNG with high impact on the exoplanetary research. In fact GIARPS will combine HARPS-N and GIANO-B, the high resolution spectrograph of TNG in the near infrared, providing simultaneous observations in the visible and in the near infrared bands, see [5]for details. The extension of the wavelength range will open to the GAPS community new scenarios and objectives in the study of the extrasolar planets.

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