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GIARPS@TNG: a wide wavelength range for characterization of atmosphere of exo–planets and high precision radial velocities

R. Claudi (1); S. Benatti (1); I. Carleo (1, 2), A. Ghedina (3); J. Guerra (3); G. Micela (4); E. Molinari (3, 5); E. Oliva (6); M. Rainer (7); A. Tozzi (6); C. Baffa (6); A. Baruffolo (1); N. Buchschacher (8); Cecconi M. (3); R. Cosentino (3); D. Fantinel (1); L. Fini (6); F. Ghinassi (3); M. Gonzalez (3); R. Gratton (1); A. Harutyunyan (3); N. Hernandez (3); M. Lodi (3); L. Malavolta (2); J. Maldonado (4); L. Origlia (9); N. Sanna (6); J. Sanjuan (3); S. Scuderi (10); U. Seemann (11); A. Sozzetti (12); H. Perez Ventura(3); M. Hernandez Diaz (3); A. Galli (3); C. Gonzalez (3); L. Riverol (3); C. Riverol (3)
(1) INAF Astronomical Observatory of Padova, Italy (riccardo.claudi@inaf.it); (2) Dep. of Physics and Astronomy, University of Padova, Italy; (3) INAF, Fundacion Galileo Galilei, Spain ; (4) INAF Astrophysical Observatory of Palermo, Italy; (5) INAF-IASF Milano, Italy; (6) INAF Astrophysical Observatory of Arcetri, Italy; (7) INAF Astronomical Observatory of Brera, Merate, Italy; (8) University of Geneva, Switzerland; (9) INAF Astronomical Observatory of Padova, Italy; (10) INAF Astrophysical Observatory of Catania, Italy; (11) Georg-August Universität Göttingen, Institut für Astrophysik, Göttingen, Germany; (12) Astrophysical Observatory of Torino, Pino Torinese, Italy

Abstract

Since 2012, thanks to the installation of the high resolution echelle spectrograph in the optical range HARPS-N, the Italian telescope TNG (La Palma) became one of the key facilities for the the study of the extrasolar planets. In 2014 TNG also offered GIANO to the scientific community, providing a near-infrared (NIR) cross-dispersed echelle spectroscopy covering $0.97 - 2.45$ μm at a resolution of 50,000. GIANO, although designed for direct light-feed from the telescope at the Nasmyth-B focus, was provisionally mounted on the rotating building and connected via fibers to only available interface at the Nasmyth-A focal plane. The synergy between these two instruments is particularly appealing for a wide range of science cases, especially for the search of exoplanets around young and active stars and the characterisation of their atmosphere. Through the funding scheme "WOW" (a Way to Others Worlds), the Italian National Institute for Astrophysics (INAF) proposed to position GIANO at the focal station for which it was originally designed and the simultaneous use of these spectrographs with the aim to achieve high-resolution spectroscopy in a wide wavelength range ($0.383-2.45$ μm) obtained in a single exposure, giving rise to the project called GIARPS (GIANO-B & HARPS-N). Because of its characteristics GIARPS can be considered the first and unique worldwide instrument providing not only high resolution in a large wavelength band, but also a high precision radial velocity measurement both in the visible and in the NIR arm, since in the next future GIANO-B will be equipped with gas absorption cells.

GIARPS

GIARPS ([2]) is the new configuration of HARPS–N ([3]) and GIANO – B that will allow the simultaneous use of the two spectrographs, exploiting therefore a wide wavelength range ($0.383 - 2.45\mu$m) with high resolution (115,000 in the visible and 50,000 in the NIR) obtained in a single exposure. The two instruments will be also able to work separately, so GIARPS will provide three different observing modes: a) HARPS–N only; b) GIANO – B only; c) GIARPS (both GIANO – B and HARPS–N) splitting the light with a dichroic. The simultaneous use of the two spectrographs has been obtained after the refurbishment of GIANO ([4]) in GIANO – B which allows to feed the spectrograph directly with light coming from the Nasmyth focus of the telescope by means of a preslit ([6]) instead to use fiber optics. GIANO was moved from the Nasmyth A to the Nasmyth B focus of TNG, allowing thus the coupling with HARPS–N. The light coming from the Nasmyth focus of the TNG meets at first a dichroic that reflects the visible component toward the HARPS–N FEU and transmits the near IR component to GIANO – B. This dichroic is mounted on a slide in the Nasmyth box that allows to select the preferred observing mode. This provides a significant improvement in the instrument performances, since the modal noise, given mainly in the K band by

the Z–Blan fibers, that seriously affected the shape of the spectra and the overall efficiency of the instruments (in particular in the K band), is now removed.. GIANO – B dewar is rigidly connected to the fork of the TNG by a structure able to sustain a burden of about 2000 kg and it is rigid enough in order to not add vibration modes to those naturally generated by the movements of the telescope (Jitter, tracking etc.). In the Preslit there will be inserted an absorption cell that will provide a stable reference spectrum for high precision radial velocity measurements. To minimize systematic errors the gas cell will be filled with gases (in particular acethylene, ammonia and an isotopologue of methane) at very low value of pressure aiming to reduce the pressure-induced line-shift and to exploit the intrinsically narrower lines ([5]). For this reason, for a given mixture of gases, a long cell (1.5 m long) filled at low pressure should be always preferred to a shorter cell filled at higher pressures. In the mean time GIARPS can use both the instrument for high resolution radial velocities measurements exploiting the simultaneous reference technique with HARPS-N in the visible and a CCF method based on telluric lines with GIANO–B ([1]). The use of this technique allows to reach a precision of about 10 m s^{-1} for bright stars (H$\leq$ 5 mag) and about 70 m s^{-1} (for fainter stars, typically H$\sim$ 9 mag). The introduction of the absorption cell allows instead to reach a better precision of 3 ms^{-1}, due to the fact that the spectral features of an absorption cell are more reliable in comparison with the instability of the telluric spectrum.

Conclusions

Once GIARPS will work routinely at the telescope, TNG will have a high resolution spectroscopy station that will be unique in the northern hemisphere and up to the commissioning of NIRPS (the NIR counterpart of HARPS) at the 3.6 m ESO Telescope, the unique in this world. The flexibility of the three observing modes of GIARPS: HARPS–N alone, GIANO–B alone and GIARPS itself will allow users to select the best wavelength range useful for their preferred science case. From small bodies of the Solar System to the search for extrasolar planets will be the major science cases. For the latter, GIARPS will be the unique facility in this world that will allow to have simultaneously high precision radial velocity measurements in VIS (HARPS–N) and NIR (GIANO–B) wavelength range covering from 0.383 μm to 2.5 μm.

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