**J/A+A/593/A117** GJ 3998 RVs, S and Halpha indexes (Affer+, 2016)

HADES RV program with HARPS-N at the TNG.
GJ 3998: An early M-dwarf hosting a system of super-Earths.
Affer L., Micela G., Damasso M., Perger M., Ribas I., Suarez Mascareno A., Gonzalez Hernandez J.I., Rebolo R., Poretti E., Maldonado J., Leto G., Pagano I., Scandariato G., Zanmar Sanchez R., Sozzetti A., Bonomo A.S., Malavolta L., Morales J.C., Rosich A., Bignamini A., Gratton R., Velasco S., Cenadelli D., Claudi R., Cosentino R., Desidera S., Giacobbe P., Herrero E., Lafarga M., Lanza A.F., Molinari E., Piotto G.
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=2016A&A...593A.117A (SIMBAD/NED BibCode)

**ADC_Keywords:** Stars, double and multiple ; Stars, M-type ; Planets ; Spectroscopy ; Radial velocities
**Keywords:** techniques: radial velocities - techniques: photometric - methods: data analysis - stars: individual: GJ3998 - instrumentation: spectrographs - planets and satellites: detection

**Abstract:**
M dwarfs are considered ideal targets for Doppler radial velocity searches. Nonetheless, the statistics of frequency of low-mass planets hosted by low mass stars remains poorly constrained. Our M-dwarf radial velocity monitoring with HARPS-N can provide a major contribution to the widening of the current statistics through the in-depth analysis of accurate radial velocity observations in a narrow range of spectral sub-types (79 stars, between dM0 to dM3).

Spectral accuracy will enable us to reach the precision needed to detect small planets with a few earth masses. Our survey will bring a contribute to the surveys devoted to the search for planets around M-dwarfs, mainly focused on the M-dwarf population of the northern hemisphere, for which we will provide an estimate of the planet occurence.

We present here a long duration radial velocity monitoring of the M1 dwarf star GJ 3998 with HARPS-N to identify periodic signals in the data. Almost simultaneous photometric observations were carried out within the APACHE and EXORAP programs to characterize the stellar activity and to distinguish from the periodic signals those due to activity and to the presence of planetary companions.

The radial velocities have a dispersion in excess of their internal errors due to at least four superimposed signals, with periods of 30.7, 13.7, 42.5 and 2.65-days. The analysis of spectral indices based on Ca II H & K and Hα lines demonstrates that the periods of 30.7 and 42.5-days are due to chromospheric inhomogeneities modulated by stellar rotation and differential rotation. The shorter periods of 13.74±0.02d and 2.6498±0.0008d are well explained with the presence of two planets, with minimum masses of $6.26\pm0.79 M_{Earth}$ and $2.47\pm0.27 M_{Earth}$ and distances of 0.089AU and 0.029AU from the host, respectively.

**Description:**
In this table we report the observing log for the GJ3998 spectra and the radial velocities, S, and Hα indexes.
The star GJ3998 has been monitored from BJD=2456439.6 (26 May 2013) to BJD=2457307.8 (12 October 2015).

We obtained a total of 136 data points spanning 869-days. The spectra were obtained at high resolution (R=115000) with the optical echelle spectrograph HARPS-N with exposure times of 15 minutes and an average signal-to-noise ratio (S/N) of 45 at 5500Å. Of the 136 epochs, 76 were obtained within the GAPS time and 60 within the Spanish time.

Observations were gathered without the simultaneous Th-Ar calibration, which is commonly used to correct for instrumental drifts during the night. The M-type stars of the HADES program were observed by the Italian team in conjunction with other GAPS targets, which used the Th-Ar simultaneous calibration, therefore we estimated the drift data between the two fibers (star and reference calibration) for each night from these observations and evaluated the interpolated drift for GJ3998 (0.7m/s).

Data reduction and spectral extraction were performed using the Data Reduction Software (DRS, Lovis & Pepe, 2007A&A...468.1115L, Cat. J/A+A/468/1115). RVs were measured by means of a weighted cross-correlation function (CCF) with the M2 binary mask provided with the DRS. The RVs were also measured by matching the spectra with a high S/N template obtained by coadding the spectra of the target, as implemented in the TERRA pipeline (Anglada-Escude & Butler, 2012ApJS..200...15A, Cat. J/ApJS/200/15), which provides a better RV accuracy when applied to M dwarfs.

We list the observation dates (barycentric Julian date or BJD), the signal-to-noise ratios (S/Ns), the radial velocities (RVs) from the DRS and TERRA pipelines (indicated with a T) and the Hα and S indexes, calculated both by the TERRA pipeline and by an independent

method described in the text. The RV errors reported are the formal ones and do not include the jitter term. The S index and Hα errors are calculated as described in the text and do not take into account the photon noise. The S index and Hα errors derived from the TERRA pipeline are due to photon noise through error propagation.

**Objects:**

| RA (2000) | DE | Designation(s) |
|---|---|---|
| 17 16 00.64 | +11 03 27.6 | GJ 3998 = BD+11 3149 |

**File Summary:**

| FileName | Lrecl | Records | Explanations |
|---|---|---|---|
| ReadMe | 80 | . | This file |
| tablea1.dat | 102 | 136 | Observing log, RVs, S and Halpha indexes of GJ3998 |

**Byte-by-byte Description of file:** tablea1.dat

| Bytes | Format | Units | Label | Explanations |
|---|---|---|---|---|
| 1- 10 | F10.5 | d | BJD | Barycentric Julian date (BJD-2456000) |
| 12- 15 | F4.1 | --- | S/N | Signal to noise ratio |
| 17- 23 | F7.3 | m/s | RVT | Radial velocities with TERRA (1) |
| 25- 29 | F5.3 | m/s | e_RVT | Error of RVs with TERRA (1) |
| 31- 40 | F10.3 | m/s | RVD | Radial velocities with DRS (2) |
| 42- 46 | F5.3 | m/s | e_RVD | Error of RVs with DRS (2) |
| 48- 53 | F6.4 | --- | SindT | S index with TERRA (1) |
| 55- 60 | F6.4 | --- | e_SindT | Error of S index with TERRA (1) |
| 62- 67 | F6.4 | --- | HalphaT | Halpha index with TERRA (1) |
| 69- 74 | F6.4 | --- | e_HalphaT | Error of Halpha index with TERRA (1) |
| 76- 81 | F6.4 | --- | Sind | S index with our method (3) |
| 83- 88 | F6.4 | --- | e_Sind | Error of S index with our method |
| 90- 95 | F6.4 | --- | Halpha | Halpha index with our method (3) |
| 97-102 | F6.4 | --- | e_Halpha | Error of Halpha index with our method |

**Note (1):** TERRA pipeline (Anglada-Escude & Butler, 2012ApJS..200...15A).
Average radial velocity has been subtracted from all the radial velocities.
**Note (2):** Data Reduction Software (DRS v3.7, Lovis & Pepe, 2007A&A...468.1115L).
Absolute radial velocities.
**Note (3):** see paper for details.

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**(End)** Patricia Vannier [CDS] 26-Aug-2016

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