SF2A 2025
A. Siebert, K. Baillié, M. Béthermin, F. Cantalloube, E. Josselin, N. Lagarde, J. Malzac, J. Richard, L. Selliez, O. Venot (eds)

TOWARDS THE CONFIRMATION OF A NEW ULTRA-SHORT PERIOD PLANET ORBITING A M-TYPE STAR

C. Gourvès[1], A. Strugarek[1,], C. Moutou[2], J. Morin[3], P. Petit[2,], A. Dyrek[4], S. N. Breton[5], R. A. García[1,], A. F. Lanza[5,], S. Mathur[6,7] and A. R. G. Santos[8]

Abstract. With the detection of thousands of exoplanetary systems, previous studies have identified a dearth of close-in exoplanets around fast rotating stars, which can be attributed to strong star-planet tidal and magnetic interactions. These systems evolve rapidly, which makes their detection particularly challenging. To increase the size of the sample of short-period star-planet systems, going beyond detections by transit is necessary. To do so, we applied a method based on phase-curve modulations, which has already proven successful through the discovery of four exoplanets. We identified 88 non-transiting candidates in the *Kepler* dataset, with orbital periods between 4 hours and 2.3 days. Remarkably, 55 of them would join the class of ultra-short-period planets, a population of particular interest for studying extreme star-planet interactions. To confirm these candidates, we initiated radial velocity follow-up with the SPIRou spectrograph at CFHT. A first allocation of 2.7 hours of Director's time on KIC 12060710 yielded a preliminary confirmation of existence and mass estimate for its substellar companion, which orbits the star in 9 hours. Additional observations have been requested at CFHT to secure this confirmation and to extend the monitoring to two other bright M-dwarfs from our 88 star sample.

Keywords: Methods: data analysis – Planet-star interactions – Planets and satellites: detection – Stars: solar-type – Techniques: radial velocities

1 Introduction

Exoplanetary detection methods have revealed an unexpected diversity of star-planet systems, with more than 6,000 exoplanets already detected. The volume of available data made it possible to move beyond case studies and investigate the statistical properties of exoplanet populations. In this context, McQuillan et al. (2013) first unveiled the presence of a dearth of close-in exoplanets around fast rotators. To understand if this gap arises from observational biases or from underlying physical processes, García et al. (2023) demonstrated that exoplanets can actually exist in this region, but are expected to evolve rapidly under strong star-planet magnetic and tidal interactions (e.g. Ahuir et al. 2021). Because of their short lifetimes, such systems are therefore statistically more difficult to detect. To overcome this limitation, we recently proposed a complementary approach (Gourvès et al. 2025), based on a method that has already enabled the discovery of four exoplanets (Faigler et al. 2013; Lillo-Box et al. 2021). This observation technique is based on detecting subtle brightness modulations caused by non-transiting exoplanets in the stellar photometry (see Shporer 2017). These signals arise from three main effects: (i) reflected light and thermal emission from the companion's atmosphere (alike a phase curve but with no transits/eclipses), (ii) tidal distortion of the host star, and (iii) Doppler boosting, which alters the observed flux as the star moves relative to the observer.

[1] Université Paris-Saclay, Université Paris Cité, CEA, CNRS, AIM, 91191, Gif-sur-Yvette, France
[2] Université de Toulouse, CNRS, IRAP, 14 avenue Belin, 31400 Toulouse, France
[3] Laboratoire Univers et Particules de Montpellier (LUPM) Université de Montpellier, CNRS 34095 Montpellier, France
[4] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[5] INAF - Osservatorio Astrofisico di Catania, Via S. Sofia, 78, 95123 Catania, Italy
[6] Instituto de Astrofísica de Canarias, La Laguna, Tenerife, Spain
[7] Departamento de Astrofísica, Universidad de La Laguna, La Laguna, Tenerife, Spain
[8] Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP, Rua das Estrelas, PT4150-762 Porto, Portugal

© Société Française d'Astronomie et d'Astrophysique (SF2A) 2025

2 Searching for non-transiting exoplanets in the *Kepler* photometry

Since non-transiting systems are statistically expected to be far more numerous than transiting ones, observing them could increase our chances of detecting planets close to their host star. To avoid confusion with stellar rotation signals (e.g. García et al. 2014), we restricted our analysis to FGKM main-sequence and subgiant stars for which we know the rotation period (see Santos et al. 2019, 2021). For each target, we searched for a power excess in the light-curve periodogram, indicative of a close-in companion. We then cross-checked our detections against existing catalogues to remove contaminants, and finally carried out a visual inspection of the phase-folded light curves and their wavelet decompositions. Using this approach, we uncovered 88 candidates with orbital periods ranging from 4 hours to 2.3 days, as seen on Figure 1. This study was published in Gourvès et al. (2025) where all details on the procedure can be found. Interestingly, nearly two-thirds of them have orbital periods shorter than a day. If confirmed, this population could directly relate to the dearth of close-in exoplanets around fast rotators identified by McQuillan et al. (2013, see dashed black line in Fig. 1) and interpreted by García et al. (2023) as the outcome of strong tidal and magnetic interactions.

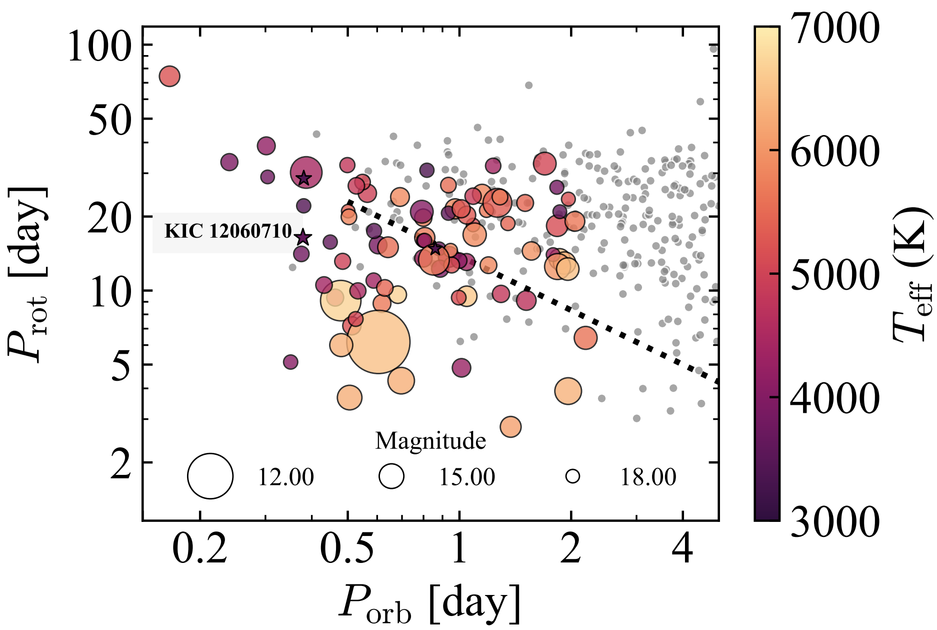

Fig. 1. Rotational period of the star as a function of the orbital period of the substellar companions, adapted from Gourvès et al. (2025). The colour-coded points are the 88 non-transiting exoplanet candidate systems, with the size of the dots being a function of the *Kepler* apparent magnitude of the host star, sourced from Brown et al. (2011). The star symbols represent KICs 12060710, 7847566, and 6370174. The colorbar shows the temperature $T_{\rm eff}$, sourced from Berger et al. (2020). The grey sample in the background consists of 576 confirmed single-planet-host main-sequence solar-like stars with a rotation period obtained by García et al. (2023). The dashed black line corresponds to the fit of the lower envelope of points obtained by McQuillan et al. (2013).

3 The case of KIC 12060710: towards the confirmation of non-transiting candidates

In order to confirm the existence of the 88 detected non-transiting exoplanets, independent observations with a different detection method are required. However, because of the faintness of most *Kepler* targets, such a follow-up is particularly challenging. To overcome this limitation, we turned to the SPIRou spectrograph at the Canada-France-Hawaii Telescope (CFHT), a powerful near-infrared instrument ideally suited to confirm planetary companions around M-dwarfs (Donati et al. 2020). Being the brightest among the M-type star candidates of our original list of 88, KIC 12060710 (see Fig. 1) is therefore the most suited target to initiate the confirmation of these newly detected non-transiting objects as exoplanets. The candidate companion identified around this star has an orbital period of around 9 hours.

In August 2025, we were granted CFHT Director's time, providing 2.7 hours of SPIRou observations. To derive the radial velocity measurements, a line-by-line (LBL) approach was used (e.g. Artigau et al. 2022). The data was compared to a simple sinusoidal model representing the expected radial velocity signal. The resulting measurements, presented in Figure 2, already reveal variability consistent with the presence of a companion around KIC 12060710, with an orbit of about 9 hours, demonstrating the feasibility of such monitoring.

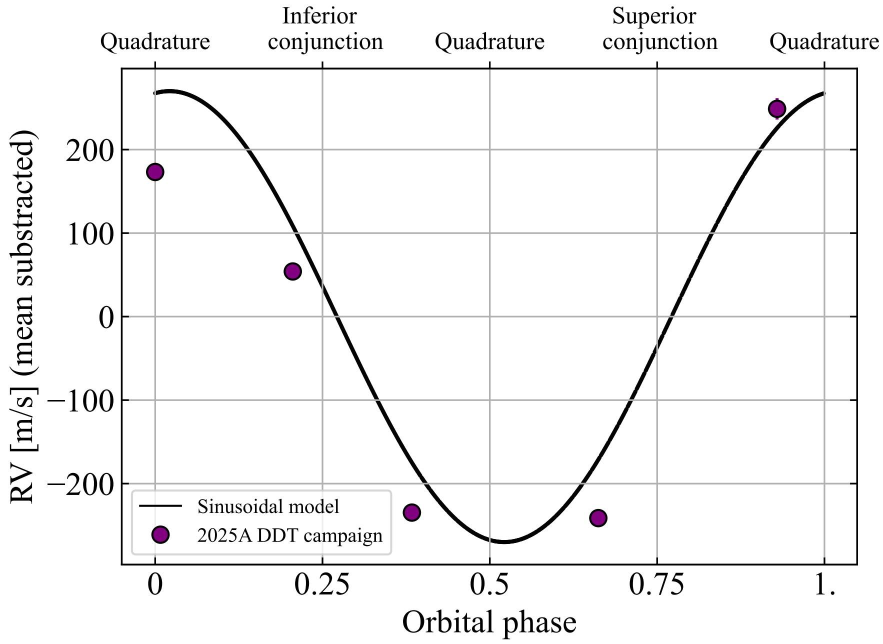

Fig. 2. Radial velocity measurements for KIC 12060710 obtained from 2.7 hours of SPIRou observations. The purple points were derived using the LBL approach, with error bars smaller than the marker size. The amplitude of the signal is consistent with expectations for such a system. The black curve shows a simple sinusoidal model approximating the expected radial velocity variation for KIC 12060710.

Considering the first radial velocity measurements obtained for KIC 12060710, we can provide a preliminary estimation of the planetary mass of the detected companion. Because of the close proximity of the object to its host star, we can assume a circular orbit (e.g. Mazeh 2008). The companion's mass $M_{\rm p}$ can then be expressed as

$$M_{\rm p} \sin i = K \left(\frac{P_{\rm orb} M_\star^2}{2\pi G} \right)^{\frac{1}{3}} ,$$

with $P_{\rm orb}$ the orbital period of the object, K the semi-amplitude radial velocity value, G the gravitational constant, and $M_\star$ the stellar mass. The $P_{\rm orb}$ and $M_\star$ values are respectively taken from Gourvès et al. (2025) and Berger et al. (2020).

By taking the maximum value of K (see Fig. 2), we obtain a $M_{\rm p} \sin i$ value of $0.576^{-0.123}_{+0.123} M_{\rm Jup}$. Assuming a maximal orbital inclination of 72°(see Gourvès et al. 2025), the minimum planetary mass of this object would be of $0.605 M_{\rm Jup}$, a value consistent with previously detected exoplanets orbiting M-type stars with similar orbital periods (e.g. Sanchis-Ojeda et al. 2015; Smith et al. 2018; Wong et al. 2021).

4 Conclusion

Among our 88 candidates, we identified 13 F-type, 23 G-type, 37 K-type, and 15 M-type stars exhibiting a signature consistent with the presence of a non-transiting planetary companion in a close orbit. Notably, 55 of them would expand the current known sample of ultra-short-period (USP) planets. These objects, characterised by orbital periods shorter than one day, have in recent years attracted considerable interest (e.g. Sanchis-Ojeda et al. 2014; Schmidt et al. 2024; Tu et al. 2025). If confirmed, our sample of USP exoplanets could represent key laboratories for studying processes such as intense magnetic and tidal interactions (e.g. Mathis 2018; Strugarek 2018), tidal heating (e.g. Lanza 2021), atmospheric escape (e.g. Owen 2019), or orbital decay (e.g. Collier Cameron & Jardine 2018).

To demonstrate the viability of SPIRou radial velocity follow-up for our *Kepler* faint targets, we observed KIC 12060710 in August 2025. These first measurements are consistent with the presence of an exoplanet and confirm the feasibility of such observations. Nevertheless, the phase coverage remains too limited to confirm with certainty this exoplanet. To address this, we have requested an additional 25 hours of SPIRou observations, not only to secure the confirmation of KIC 12060710, but also to expand our study to other promising candidates. We selected the two other brightest M-dwarfs in the Gourvès et al. (2025) catalogue: KIC 7847566 and KIC 6370174 (see Fig. 1). Both show photometric signatures consistent with the presence of non-transiting companions, and could contribute to the growing catalogue of USP exoplanets. The field of USP exoplanet detection is expanding rapidly and future missions such as the PLAnetary Transits and Oscillations of Stars mission (PLATO, Rauer et al. 2025), scheduled for launch in 2026, will play a decisive role. PLATO's emphasis on brighter targets (Montalto et al. 2021) will significantly increase the number of systems accessible to ground-based follow-up observations.

We warmly thank the organisers of the SF2A 2025 conference, which provided the opportunity to connect with collaborators. Without these interactions, the resulting progress reported here would not have been possible. A.S. and C.G. acknowledge funding from the European Research Council project ExoMagnets (grant agreement no. 101125367). A.S. acknowledges funding from the Origins project DynamEarths. A.S. acknowledge funding from the Programme National de Planétologie (INSU/PNP). R.A.G., C.G., and A.S, acknowledge the support from the GOLF and PLATO Centre National D'Études Spatiales grants. S.N.B acknowledges support from PLATO ASI-INAF agreement no. 2022-28-HH.0 "PLATO Fase D".

References

Ahuir, J., Strugarek, A., Brun, A. S., & Mathis, S. 2021, A&A, 650, A126
Artigau, É., Cadieux, C., Cook, N. J., et al. 2022, AJ, 164, 84
Berger, T. A., Huber, D., van Saders, J. L., et al. 2020, AJ, 159, 280
Brown, T. M., Latham, D. W., Everett, M. E., & Esquerdo, G. A. 2011, AJ, 142, 112
Collier Cameron, A. & Jardine, M. 2018, MNRAS, 476, 2542
Donati, J. F., Kouach, D., Moutou, C., et al. 2020, MNRAS, 498, 5684
Faigler, S., Tal-Or, L., Mazeh, T., Latham, D. W., & Buchhave, L. A. 2013, APJ, 771, 26
García, R. A., Gourvès, C., Santos, Â. R. G., et al. 2023, A&A, 679, L12
García, R. A., Mathur, S., Pires, S., et al. 2014, A&A, 568, A10
Gourvès, C., Breton, S. N., Dyrek, A., et al. 2025, A&A, 699, A226
Lanza, A. F. 2021, A&A, 653, A112
Lillo-Box, J., Millholland, S., & Laughlin, G. 2021, A&A, 654, A9
Mathis, S. 2018, in Handbook of Exoplanets, ed. H. J. Deeg & J. A. Belmonte, 24
Mazeh, T. 2008, in EAS Publications Series, Vol. 29, EAS Publications Series, ed. M. J. Goupil & J. P. Zahn, 1–65
McQuillan, A., Mazeh, T., & Aigrain, S. 2013, APJL, 775, L11
Montalto, M., Piotto, G., Marrese, P. M., et al. 2021, A&A, 653, A98
Owen, J. E. 2019, Annual Review of Earth and Planetary Sciences, 47, 67
Rauer, H., Aerts, C., Cabrera, J., et al. 2025, Experimental Astronomy, 59, 26
Sanchis-Ojeda, R., Rappaport, S., Pallè, E., et al. 2015, ApJ, 812, 112
Sanchis-Ojeda, R., Rappaport, S., Winn, J. N., et al. 2014, ApJ, 787, 47
Santos, Â. R. G., Breton, S. N., Mathur, S., & García, R. A. 2021, APJS, 255, 17
Santos, Â. R. G., García, R. A., Mathur, S., et al. 2019, APJS, 244, 21
Schmidt, S. P., Schlaufman, K. C., & Hamer, J. H. 2024, AJ, 168, 109
Shporer, A. 2017, ASP, 129, 072001
Smith, A. M. S., Cabrera, J., Csizmadia, S., et al. 2018, MNRAS, 474, 5523
Strugarek, A. 2018, in Handbook of Exoplanets, ed. H. J. Deeg & J. A. Belmonte, 25
Tu, P.-W., Xie, J.-W., Chen, D.-C., & Zhou, J.-L. 2025, Nature Astronomy, 9, 995
Wong, I., Shporer, A., Zhou, G., et al. 2021, AJ, 162, 256