Detection and study of the multiplanetary system WASP-148

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IPSA and AAVSO : start of a collaboration between French students and AAVSO

IPSA is a school that trains engineers in aeronautics and space in France. It has been in existence for 60 years and students can set up associations to participate in participatory science projects. It is the case of the association IPSA Vega, of which we are part with Anica Lekic, teacher, and which registered with the AAVSO. IPSA Vega students were able to attend lectures, meet ambassadors and use telescope time for their projects.

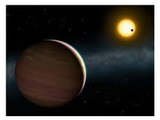
The IPSA also provides in its master cycle a course of initiation to research (called CIRI) on the detection of exoplanets. After this course we wanted to continue on the theme in the framework of an end of study project with the same teacher. It is within the framework of this project called Master IPSA Project (PMI) that we were able to use the AAVSO telescopes and to participate in a participative science campaign on the detection of the transit of Wasp-148b.

This kind of project is regularly proposed in the astronomy association by our teacher and allows to combine teaching and research within the framework of amateur-professional collaborations like the one we did with the team of the Institut d'Astrophysique de Paris (IAP) through the AFA observation campaign.

Astronomy accessible to all : the AFA's collaborative campaign

Founded in December 1946, the French Association of Astronomy (AFA) offers the oportunity to everyone to discover astronomy. After the discovery of a multiplanetary system in 2020, the AFA called the non-professional observers to take part in scientific research in 2021 to deepen the subject.
The aim of the campaign was to validate the parameters such as :

- eccentricity
- inclination
- planet's mass



but also, to determine the existence or not of a timing variation which could demonstrate the presence of other planets around the studied star.

To detect a transit, it is necessary to measure the luminous intensity of the studied star: if a planet passes in front, its luminosity decreases slightly. Dynamics can also be studied in systems composed by more than one planet when transit-timing variations (TTVs) are detected. TTVs are particularly difficult to observe from the ground as transit timing depends on short-duration events easily perturbated by any kind of noise. As a result, the detection of exoplanets from the ground is a challenge even nowadays.

Contact us !

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WASP-148b : From the discovery to the study

In 2020, French astronomers discovered an extrasolar system with two interacting planets. In fact, they conclude after studying the movement of the star WASP-148 that two planets revolve around it : Wasp-148b and Wasp-148c

	Wasp-148
Distance	248.1 (±1.6) pc
Apparent magnitude	12
Mass	1 (± 0.08) Msun
Teff	5460 (± 130) K
Radius	1.03 (± 0.2) Rsun
Metallicity [Fe/H]	0.11 (± 0.08) dex

	Wasp-148b	Wasp-148c
Mass	0.29 (± 0.025) Mj	
Radius	0.72 (± 0.055) Rj	
Orbital period	8.8 day	34.5 day
Eccentricity	0.22 (± 0.063) deg	0.359 (±0.086)
	59 (±20.0) deg	14 (±17.0) deg
Inclination	89.8 (±0.27) deg	
Temperature	940 (± 80) K	590 (± 50) K

Characteristics of Wasp-148 and its planets

WASP-148 is a star from Hercules. The constellation remains above the horizon for about 16 hours a day, allowing a nice viewing window to focus on WASP-148b. WASP-148 is characterized as an inactive, slowly rotating late dwarf. The studied system is located 810 light years from Earth and is older than the Sun

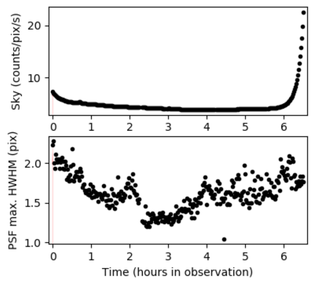
Wasp-148 system was discovered at OHP (France)

The Wasp-148b campaign observation allowed us to work with amateur astronomers from the American Association of Variable Star Observers (AAVSO). We participated in this scientific study with them by analyzing the images they obtained from different observatories in the United-States.

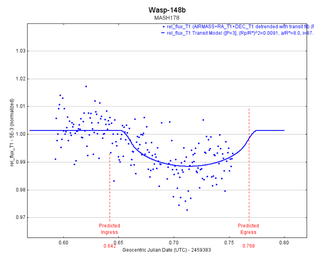
After having used several software to correct the luminosity and determine the position of the wanted object (AstroImageJ, Siril ...), we moved on to a photometric study using reference stars to calibrate the measurements (TYC 3083-757-1, TYC 3083-1080-1 and USNOA2 1275-9128575). Thanks to our results, we were able to obtain significant light curves validating the transit of WASP-148b, one of the 2 planets orbiting around WASP-148. Our work has finally been shared to the AFA to feed their database.

These observations constitute the first detection from the ground of variations in timing for a resonant planetary system. The different observations of the system have proven that the two planets WASP-148b and WASP-148c periodically find themselves in the same configuration after having performed a different number of orbits: the first one rotates 4 times faster than the second one implying that the system approaches 4:1 resonance.

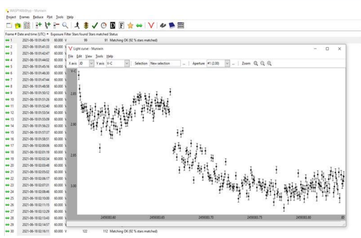
Results : Some lightcurves we obtained with the AAVSO BSM telescopes



Light curve obtained with Hopes



Light curve obtained with AstroImageJ



Light curve obtained with Muniwin (HYP telescope)

Unfortunately, because of either the meteorological conditions and the sunrise, the light curves we obtained are not complete. However, they permit the validation of the transit time and duration.

The three photometry softwares that amateurs can use, gave similar results with the 3 reference stars and the 2 data sets obtained with the AAVSO BSM telescopes. The easiest to use is in our opinion HOPS, but Muniwin also gives a convincing light curve quite easily. Only SIRIL requires some mastery of pre-processing. Regardless of the software, the results are in line with the predictions of the research team that discovered the target, and further observing campaigns will take place in 2021 and 2022. Thanks again to Dave, Ken and George from the AAVSO for their advice and help.

A project for the future : WASP_148b study is not ended

The different observations of the system have proven that the two planets WASP-148b and WASP-148c periodically find themselves in the same configuration after having performed a different number of orbits: the first one rotates 4 times faster than the second one implying that the system approaches 4:1 resonance. The coming months and years, the WASP-148 multiplanetary system will be the subject of numerous theoretical studies and additional observations, which will allow us to refine the measurements of its properties and to better understand its structure and evolution.