

PLANETARY NEBULAE CONFIRMATION

Recommended equipment : [Alpy](#), [Lisa](#)

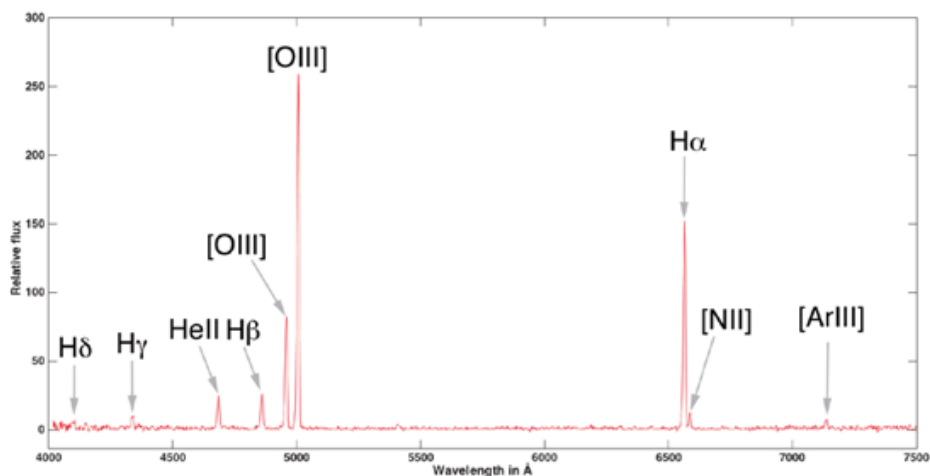
Time : about 4 h

For several years, amateur astronomers have been discovering probable planetary nebula candidates thanks to their own images or by scrutinizing professional surveys available on the Web.

The catalogues of these likely candidates are available on : <http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=J/other/LAstr/114.54>

To confirm the nature of a candidate, it is necessary to acquire its spectrum and highlight its characteristic spectral signature : the lines [OIII] 4959-5007 and H α must be in emission. Other parameters are taken into account such as the ratio of the two lines [OIII] 4959 and [OIII] 5007. Some other lines can also be in emission (H β , [OI], HeI, HeII, [SII], [NII]).

The [Lisa](#) et [Alpy](#) spectrographs are particularly well suited for this work. Depending on your setup, it will be necessary to use a rather large slit (35 to 50 μ) in order to increase the flux entering the spectrograph, the resolution will be lower but the goal here is to show the spectral signature of this kind of object.

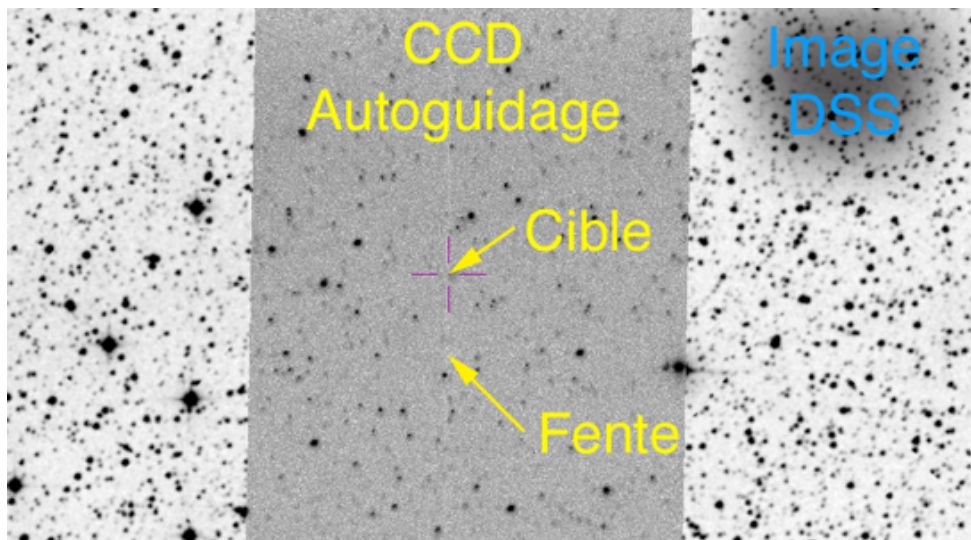


A typical planetary nebula spectrum obtained with a LISA

Methodology

Once you've determined your target candidate, you need a field chart made with free software available online such as [Aladin](#).

We enter the coordinates of the target in Aladin and we can see the chart of the target whose magnitude is very weak (magnitude generally greater than 16). The image of the autoguiding sensor field can be overlaid on the image produced by Aladin.

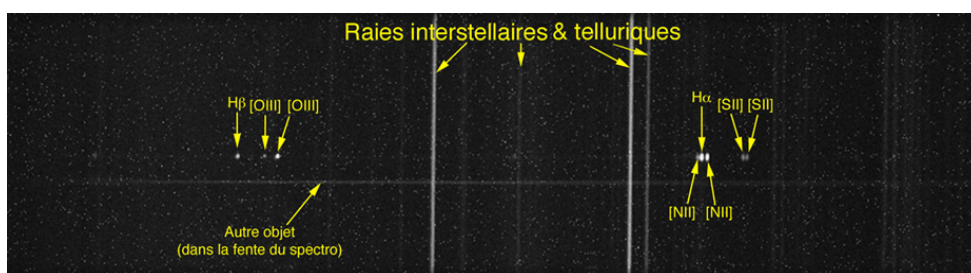


Example of overlaying the autoguiding sensor field with the DSS image in Aladin

It's not uncommon that the target doesn't stand out on the autoguiding sensor because of the weak source of light. We will position the slit of the spectrograph depending on the surrounding stars. Save an image of the autoguiding sensor field on your PC in order to attach it to the future observation report of this target. The autoguiding will be done on a bright star close to the target while you check that the slit is on the target. Once centered, we start the autoguiding then we go to the acquisitions of the spectra :

1- Produce a first image with a unit exposure time of 900 to 1200 seconds.

If there is no apparent signal, drop this target. This phase is delicate, an adjustment of the thresholds is sometimes necessary to try to perceive the signal. If nebular lines appear, acquisition can continue. The image below shows the appearance of a raw unit spectrum of a rather punctual NP candidate.



Example of a raw spectrum as it appears on the PC screen during acquisitions by finely tuning the display thresholds.

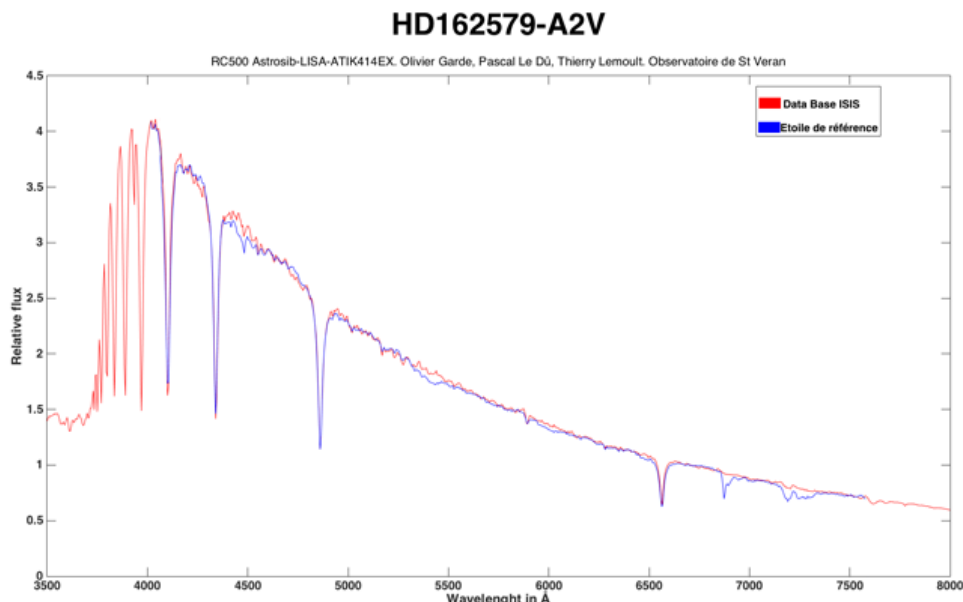
2- Take n poses of 900 seconds. n depends on the appearance of the unit spectrum and can vary from 3 to 12 depending on the targets. The goal is to increase the signal to noise ratio in order to highlight the main emission lines.

- 3- Take a spectrum of a calibration lamp (Neon), without modifying the position of the spectrograph or the telescope.
- 4- To perfectly calibrate the spectrum, it's necessary to take the spectrum of a reference star (A or B) close to the target and at the same height in the sky. For that we will use the excel spreadsheet offered by François Teyssier and available [here](#). Pointing the reference star : take a series of 7 to 9 unit spectra whose exposure times depends on the magnitude of the star (between 2 and 5 seconds most of the time because of the brightness).
- 5- Take a spectrum of the calibration lamp (Neon), without modifying the position of the spectrograph and/or the telescope.
- 6- Switch to the next target. Note that each spectrum is made exactly at the same x and y coordinates of the slit which allows for better accuracy during processing.
- 7- At the end of the acquisitions, a series of 21 to 33 images use a tungsten lamp for the flats.

Spectrum processing

The processing will be carried out with [ISIS](#) which makes it possible to choose the right treatment zone of the spectrum.

The reference star is first processed to calculate the instrumental and atmospheric effect response at the time of observation. Once the processing is done, the resulting spectrum is compared to a generic spectrum of a star of the same type in the ISIS database. The resulting Planck profile is verified.

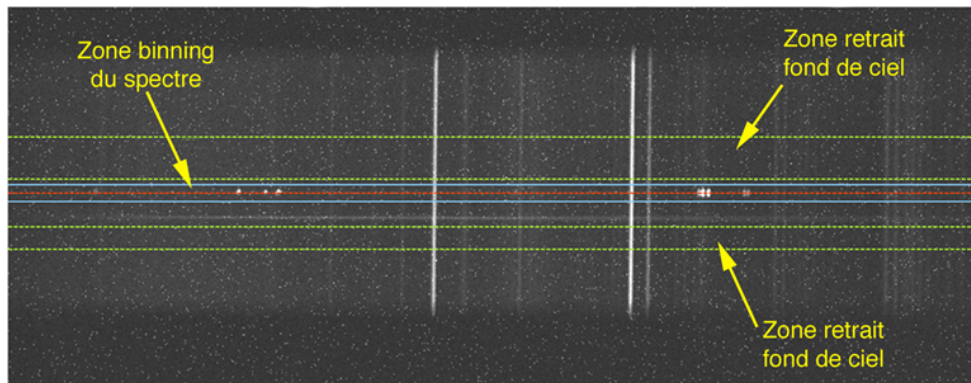


The example above shows the result with a A2V star. The red curve is the reference curve of the ISIS database and the blue curve of the reference star obtained with the spectrograph. The two curves must be superimposed.

The target is then processed. The job is now to select the area of interest within the image, from which the final spectrum of the object will be calculated. Two areas containing only the sky background need to be identified in order to be subtracted from the area of interest containing the object's signal. The goal

here is to eliminate all lines of light, interstellar pollution as well as the Earth's atmosphere or even another nebula that could be in the same line of sight as the NP. Only the signal related to the object must be taken into account.

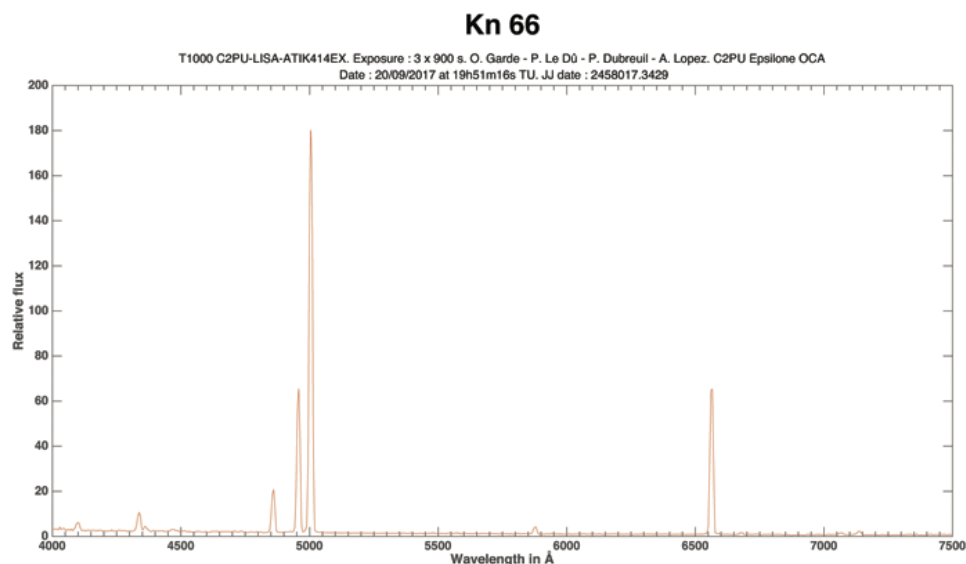
This work is relatively easy in the case of a punctual NP. It becomes harder for a diffuse NP because the different zones to be determined are difficult to identify. Often, several tests are necessary.



The example above shows the treatment performed on a candidate NP punctual, so “easy”. The zone delimited in blue contains the area of the spectrum of the NP that will be treated. The height is adjusted to contain the entire signal of the NP. Do not hesitate to push the thresholds of the histogram for visualization. It is in this zone that the spectrum is calculated (by adding the pixels of each column of the zone).

The two green areas are selected at the top and bottom of the spectrum. They do not have star spectra that could disturb the measurements in the area of interest. These sky-bottom areas are positioned closest to the area of the NP spectrum calculation.

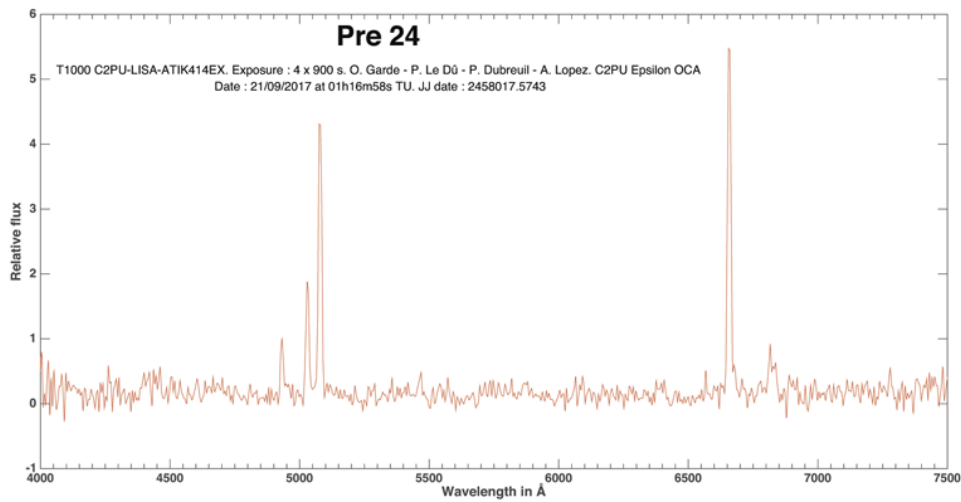
Once the treatment is done, we finally obtain a spectrum that can look like this :



Example of the KN 66 candidate : we can see the various nebular lines

Spectrum analysis

We will try to analyze the spectra obtained to determine if it is indeed a planetary nebula and not another object such as a proto-star, a nova, a galaxy or other object that does not have the spectral signature of a planetary nebula like the example below which is actually a Seyfert galaxy not yet listed.



Pre24 spectrum showing nebular lines but strongly shifted in the red. We can also calculate its redshift z which in this case is $z = 0.014$ is a velocity of more than 4300 km/s. We can therefore exclude this candidate who is not an NP.

Publication of results

The collection of spectral data is done by Pascal Le Dû who gathers the various spectra obtained to send them to Quentin Parker and his team of the University of Hong Kong who maintains the HASH planetary nebula database :

<http://hashpn.space/>

You can download a report form template [here](#) and send it to **ledu at shom dot fr** with all spectra data files (.fits, .dat, .log et .xml)

Regularly the astronomical database is updated of the latest confirmations where the objects pass from the stage “Possible Planetary Nebula” to the stage of “Planetary Nebula” in full share as on the example below :

PN Ldu 13

other query modes: Identifier query, Coordinate query, Criteria query, Reference query, Basic query, Script submission, TAP, Output options, Help

Query: PN Ldu 13 C.D.S. - SIMBAD4 rel 1.5.8 - 2016.09.17CEST12:26:16

Available data: Basic data • Identifiers • Plot & images • Bibliography • Measurements • External archives • Notes • Annotations

Basic data:

NAME PN LDU 13 -- Planetary Nebula

Other object types: PN (Ref, PN), ISM (IPHASX)

ICRS coord. (ep=J2000): 23 38 40.430 +61 41 40.90 [] D 2015LAstr.129a..42P

FK5 coord. (ep=J2000 eq=2000): 23 38 40.430 +61 41 40.90 []

FK4 coord. (ep=B1950 eq=1950): 23 36 18.75 +61 25 03.7 []

Gal coord. (ep=J2000): 114.4192 +00.0315 []

Angular size (arcmin): 1.02 1.02 90 (Opt) D 2014MNRAS.443..338BS

SIMBAD query around with radius 2 arcmin

Interactive AladinLite view

Example of a Nebula that has been confirmed in spectroscopy

Portal Simbad Vizier Aladin X-Match Other - Help

PN RA 9

other query modes : Identifier query Coordinate query Criteria query Reference query Basic query Script submission TAP Output options Help

Query : PN RA 9 C.D.S. - SIMBAD4 rel 1.5.8 - 2016.09.17CEST12:25:04

Available data : Basic data • Identifiers • Plot & images • Bibliography • Measurements • External archives • Notes • Annotations

Basic data :

NAME PN Ra 9 -- Possible Planetary Nebula

Other object types: **PN?** (Ref)

ICRS coord. (ep=J2000) : 20 31 09.0 +21 21 41 [] D 2015LAstr.129b..42P SIMBAD query around with radius 2 arcmin

FK5 coord. (ep=J2000 eq=2000) : 20 31 09.0 +21 21 41 []

FK4 coord. (ep=B1950 eq=1950) : 20 28 55.9 +21 11 31 []

Gal coord. (ep=J2000) : 063.7177 -10.5591 []

Interactive AladinLite view



Example of a target that has not been confirmed yet

References :

Planetary Nebula Confirmation Mission Report to St Veran Observatory

: <http://o.garde.free.fr/RapportMissionCALAI-2016BD.pdf>

Planetary Nebula Confirmation Mission Report to the OCA on the Calern observatory : <http://o.garde.free.fr/RapportMissionCalern2017.pdf>

The Pascal Le Dû website : <http://www.cielocéan.fr>

The APN VII congress poster in Hong

Kong : http://www.cielocéan.fr/uploads/images/FichiersPDF/Poster_APN%20VII%20v1-1.pdf

The issues of the french magazine l'Astronomie relating the confirmations of planetary nebulae : # 91 February 2016, # 102 February 2017 and # 114

March 2018 : <https://www.saf-lastronomie.com/revue/>

The french magazine Ciel et Espace # 558 March/April 2018

: <https://boutique.cieletespace.fr/liseuse/preview/558/view.html#!/avedocuments0/pdf/1/1/1>

Discovery of new faint northern galactic PN

: http://www.cielocéan.fr/uploads/images/FichiersPDF/RMxAA.48-2_aacker.pdf

Article in french about Pascal Le Dû observations

: http://www.cielocéan.fr/uploads/images/FichiersPDF/ASM87_SpectroGa1.pdf