CONFIRMATION OF AN APPARENT SUPERNOVA IN THE GALAXY NGC6946

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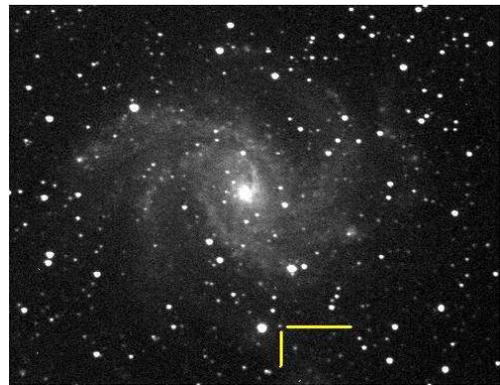INAF - Astronomical Observatory of Trieste

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1 Introduction

A long time ago, in a galaxy far far away, a star exploded. This star exploded so violently that for a few weeks the star outshone its parent galaxy. This type of explosion is called a Supernova and makes the star to became visible far away.

To be seen by naked eye a supernova has to explode in our galaxy: the last ones were those of 1572 and 1604, observed respectively by Tycho Brahe and Keplero.

Nowadays astronomers discover more than 200 supernovae every year, and to date have been registered more than 5000 supernovae.

In the supernovae research field the amateur astronomers can give a substantial contribution to the professional projects. Amateur astronomers all over the world take thousands images of the brighter galaxies every night, with the aim to discover a supernova: they compare the new images with older ones and look for new stars.

This is a tutorial on how an amateur astronomer participating in a supernovae search program can take advantage in using Aladin (or other tools that provide access to VO data) to verify an apparent supernova. We can download the image ngc6946.fit (fig. 1) with the apparent supernova from *http://cds.u-strasbg.fr/twikiAIDA/pub/EuroVOAIDA/WP5 WorkProgrammeUsecases/ngc6946.fit* and follow the tutorial to see if it is really a new star or not.

Figure 1: Image of the host galaxy ngc6946 with the apparent supernova (pointed by the two yellow lines).

2 Supernovae

The supernovae are stars with the largest brightness variations. In a few days their brightness may rise more than 20 magnitudes, i.e. the luminosity may increase by a factor of a hundred million. After the maximum, there is a slow decline lasting several months.

The supernovae are exploding stars. In the explosion a gas shell expanding with a velocity around 10.000 km/s is ejected. The expanding gas shell remains visible for thousands of years (i.e. the supernova remnant of the Crab Nebula - M1, exploded in 1054). A few tens of such supernova remnants have

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been discovered in the Milky Way. The remnant of the actual star may be a neutron star or a black hole.

Supernovae were first categorised in 1941 when Rudolph Minkowski recognised that at least 2 different types existed, those that show hydrogen (H) in their spectra (*Type II*), and those that do not (*Type I*). In the mid-1980s as the rate of supernova discoveries increased and data quality improved, Type I supernovae were further sub-divided based on the presence of silicon (*Type Ia*) and helium (*Type Ib*) in their spectra, or neither Si nor He (*Type Ic*). It was also discovered that while Type Ia supernovae could be found anywhere and in any type of galaxy, Type Ib and Type Ic supernovae occurred primarily in populations of massive stars, similar to Type II.

We now know that Type II, Type Ib and Type Ic supernovae result from the core-collapse of massive stars, while Type Ia supernovae are the thermonuclear explosions of white dwarfs.

The supernovae are interesting in order to characterize the stellar evolution, but they allow also accurate measurements of cosmic distances. In fact a certain type of supernova has a standard luminosity, so supernovae can be used like distance indicators.

3   Aladin

Aladin is an interactive sky atlas developed and maintained by the Centre de Donnes astronomiques de Strasbourg (CDS) for the identification of astronomical sources through visual analysis of reference sky images.

Aladin fully benefits from the environment of CDS databases and services (SIMBAD reference database, VizieR catalogue service, etc.), and is designed as a multi-purpose service for use by the professional astronomical community, amateur astronomers, students and general public.

Aladin allows the user to visualize digitized images of any part of the sky, to superimpose entries from the CDS astronomical catalogues and tables, and to interactively access related data and information from SIMBAD, NED, VisieR, or other archives for all known objects in the field.

in order to be able to load a local astronomical image, we have to use the standalone version of Aladin. It is a Java application available for download at http://aladin.u-strasbg.fr/.

4   Load the local image

We have an image of the galaxy ngc6946 taken by the Col Druscè Remote Observatory Supernovae Search (CROSS) program. Our aim is to check if there is a new supernova in this image, specially in the host galaxy.
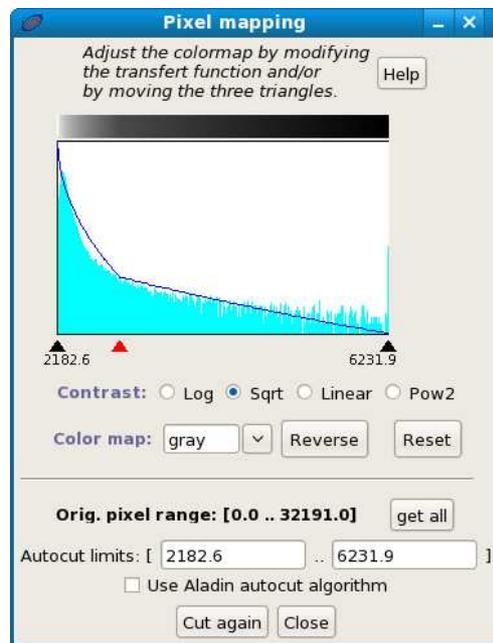

Figure 2: The mapping pixel windows.

Download the image on your pc and start Aladin. Load the image in Aladin from the menu

```
File --> Open local file.
```

Now we have our image loaded in Aladin, modify the pixel distribution in order to see it better. Open the *pixel mapping* window ("**pixel**" button on the right of the image) and check "**sqrt**" (fig. 2).

Through the buttons "**zoom**" and "**pan**" we can enlarge the image and move it if it is larger than the Aladin window.

5 Astrometrical calibration

Our image has no astrometrical calibration, so we don't have information on sources (stars, galaxies, etc.) position. In order to calibrate it we have first of all to load a calibrated image and a catalog.

Open the server selector:

```
File --> Load astronomical image
--> Aladin image server.
```

In the field "target" enter "ngc6946", then click "**submit**". Select "POSS II F (Optical R)" image and click "**submit**".

In the server selector window (fig. 3) select "**Survays**" (in the right column) and click "**submit**". We choose the 2MASS Point Sources Catalog because it provides celestial sources visible in the optical wavelength. Select "**2MASS**" and click "**submit**".

We have loaded our image, a calibrate optical image (POSS II F) and a catalog (2MASS). Now we have to calibrate our image with respect the POSS one, matching the sources.
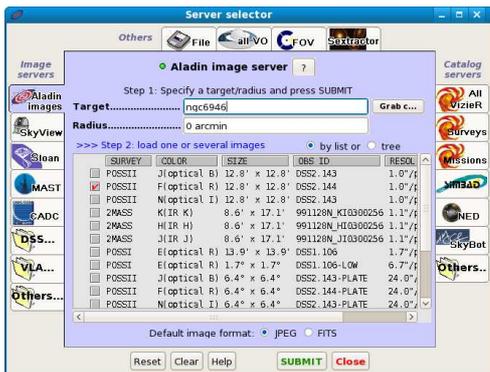

Figure 3: The Aladin catalog and image server selector.

Right-click on the plane of our image (ngc6946.fit) and select "**properties**". Press the "**new**" button on the astrometrical reduction method section. Switch to the "by matching stars" tab. In the cells of the left column pick up the coordinates (x,y) of three or four stars of our image (select the cell and click on the star). Visualize the POSS II image (click on its plane). In the cells of the right column pick up the coordinates (RA, Dec) of the corresponding three or four stars of the POSS II image (select the cell and click on the star). Click "**CREATE**" (fig. 4).
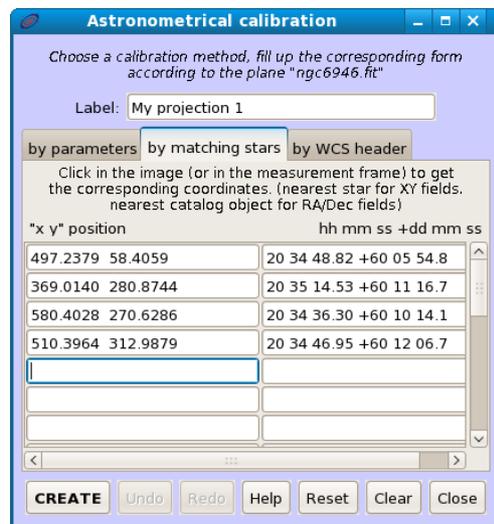

Figure 4: Star matching windows with the coordinates of four stars of our image and the same stars in the POSS calibrated one.

Now our image is calibrated, we can overlaid it on the POSS one and compare.

6 Comparison with POSS images

In order to check if in the our image there is a supernova (that is a new star) we have to compare it with an archive image taken some time before. The most useful such archive images available on the web are POSS II ones. POSS stays for Palomar Observatory Sky Survey: it is a collection of digitalized plates of all the sky taken at the Palomar Observatory.

We start comparing our image with the POSS red

one loaded before. Select the plane ngc6946.fit. Point the cursor on the icon of the plane POSS II and modify its transparency level (move to the right the little cursor on the bottom left corner of the plane icon - fig. 5) to show both images overlaid. Notice that the supernova doesn't appear in the POSS II image.

Figure 5: The cursor to modify the transparency level of the image.

The comparison between the two images can be done also by an animation (blink). Press the "**assoc**" button and select ngc6946.fit in the first field (1) and the POSS II image in the second one (2). Click "**CREATE**" and look at the animation. On the top right corner of the window there are the controls (play, pause, previous image, next image, etc.). If necessary modify the stretch of the 2 images with the button pixel.

Suggestion to equalize the pixel distribution of the two images: move on the apparent supernova and read the value of the field "pixel" (on the upper side of the Aladin window). Open the pixel distribution window of the image ngc6946.fit and insert as maximum histogram value a value little larger than that of the field "pixel", for example "**2500**". Cut the minimum value of the histogram moving the left pointer of the plot, up to remove most of the background noise. Select "**Pow2**" and click "**CUT AGAIN**".

We checked the apparent supernova doesn't appear in the POSS II red images, which is taken in the visible wavelength. To be sure that the apparent supernova is really a supernova we also have to check that it doesn't appear in other wavelengths either. We will check POSS II ir and blue, that are the wavelengths at the lower and upper edge of the red one. Open

the image server selector and select POSS II J (optical B) and POSS II N (optical I). The two new POSS images are loaded in the Aladin plane stack, repeat the same procedure as before in order to compare our image with them. Note that the apparent supernova doesn't appear in these images either, so we can be quite sure that it is really a supernova!

7 Compute the coordinates and the offset

We have checked that our new source is really a supernova. In order to advise the international community of scientists we have to accurately compute the position of the star (its equatorial coordinates) and its offset from the nucleus of the host galaxy.

In Aladin the position computation is very simple: move the cursor on the star and click on it. In the "command" field we have the coordinates of the supernova: 20:34:45.45, +60:05:56.5.

The offset from the nucleus of ngc6946 can be computed directly from the coordinates or by tracing a distance vector. Press the button "**dist**" and trace with the mouse a vector between the supernova and the nucleus of the host galaxy. In the lower part of the window (fig 6) you have the following information:

```
Dist = 3.33' (RA=53.778"/7.2s. DE=3.2')
PA = 195.7 deg
```

e.g. the distance between the two objects (3.33') and the projection along the RA and Dec components (53.778", 3.2').

8 Other supernovae in the same galaxy

Some galaxies, like ngc6946, are more likelihood to show a supernova explosion. We want to visualize all the other supernovae exploded in it: to do it we have to apply a filter to the SIMBAD catalog.

In the server selector window select the SIMBAD database, in the field "Display filter" select "**-no filter-**" (fig. 7). Then click "submit".
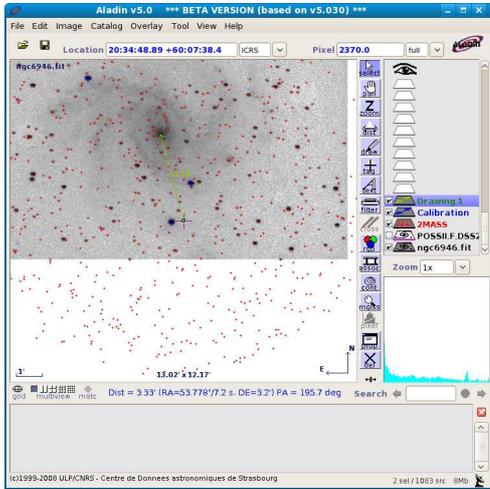
Figure 6: The distance vector between the supernova and the nucleus of the galaxy.


Figure 7: SIMBAD database in the server selector window.

In Aladin select the new loaded SIMBAD plane and click the "**filter**" button. Switch to advanced mode, in the field "your own filter definition" enter the following string:

```
$[src.class]=''SN'' {draw red squares}
```

and then click "apply". All the 9 supernovae exploded in this galaxy are visualized in the filter with red squares (fig. 8).

If you select a supernova its data appear in the measurement window. If you click on its name you
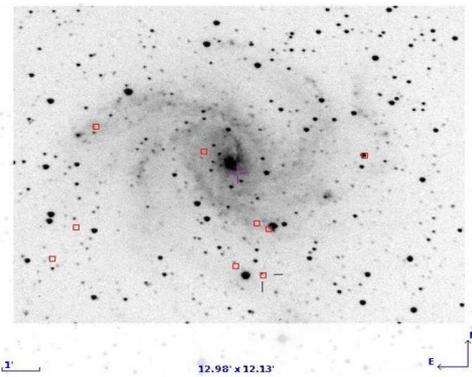
Figure 8: All the supernovae (red squares) exploded in the galaxy ngc6946.

open a window in your web browser with the SIMBAD page of the supernova (with information, references, etc.).

9 Save your work

In Aladin there are many options to save the work, you can save or print the current view, export each plane, save the original image with the astrometrical calibration, etc. The most useful option is the *stack backup*, that allows you to work off-line or continue it later. Go to the menu

```
File --> Backup the Stack
```

and choose a name for your Aladin file. The format of the file is .aj, that is an Aladin format. In the .aj file are saved all the planes with all their objects (images, catalogues, calibrations, etc). To load the .aj file into a new later session of Aladin go to the

```
File --> Load local file
```

menu and select it.