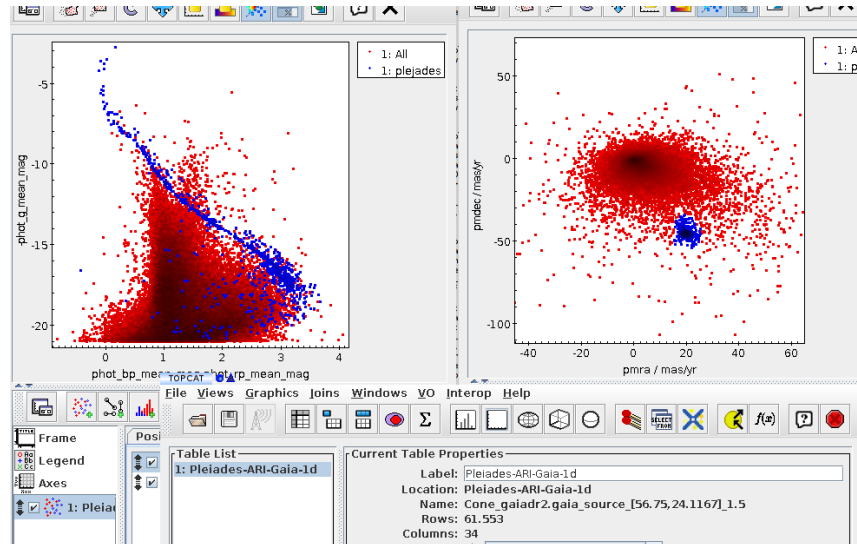


# Explore the Pleiades with TOPCAT and Aladin



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## Abstract

As stars in open star clusters are formed from the same matter at the same time and have only a small velocity dispersion, it is relatively easy to identify them from the background stars. In this tutorial, we will identify the members of the Pleiades kinematically and get an idea of our success by examining a color-magnitude diagram using TOPCAT, Aladin, and a few VO services.

**Software:** [TOPCAT](http://www.star.bris.ac.uk/~mbt/topcat/) Version 4.9, [Aladin](http://aladin.u-strasbg.fr/) Version 12.0

## 1 Starting out

In this tutorial we use TOPCAT for data access and plotting and Aladin for image access. If you do not have both installed on your machine already, install them using the following links:

Aladin: <http://aladin.u-strasbg.fr/>

TOPCAT: <http://www.star.bris.ac.uk/~mbt/topcat/>

## 2 Accessing Gaia data and plotting

- ▷ **1** *Getting candidate members from Gaia* – To obtain a data set we need to find a catalog providing proper motions, positions and color filter bands. These days of course a good choice for this is the Gaia catalog, from which we will download a subset of objects in the region of the Pleiades.

For generic searches of the type “objects within  $x$  degrees of a position on the sky”, the VO cone search protocol is straightforward. To use it, in TOPCAT click on [VO](#) → [Cone Search](#). In the Cone Search window enter [gaia dr3](#) as **Keywords** and click on [Find Services](#). This will perform a search over the VO registry for this keyword and the results will show up in the field below.

There are multiple instances of Gaia in the VO. Have a look in the service metadata window and see that next to different services providing full catalogues of different Gaia data releases, you also find services from Vizier. In principle you could use any of the services providing Gaia DR3 data and they should return the same result. In this tutorial we selected the one with the short name [DR3 lite Cone](#) – just do a left click. In the field **Object Name** enter [Pleiades](#) and then click on [Resolve](#) right of it to determine the position around which to search (name resolution uses Sesame, a service of CDS) The full Pleiades cluster has a large coverage on the sky. To dodge some problems we might run into with resource limits on the service side, we will settle for the cluster core for now and use a **Radius** of [1.5](#) degrees. With [OK](#), submit the query to the Cone Search service. After a few seconds, TOPCAT has loaded a few 10s of thousands of stars.

- ▷ **2** *Plotting proper motions* – The data set we obtained from the last step will not only contain members of the Pleiades, but also other objects. To define a subset with good candidates of members of the Pleiades, let us exploit the fact that all members of an open clusters share their proper motion (with a fairly small velocity dispersion) . This would be evident as an overdensity in a plot of the proper motion components.

Go to [Graphics](#) → [Plane Plot](#). The plot controls are in the bottom part of the plotting window. As **X axis**, choose [pmra](#), as **Y axis** choose [pmdec](#). Zoom into the center for the point cloud a bit (e.g., by using your mouse wheel). You should fairly soon see an overdensity centered somewhere around [0.5 e-5](#), [-1.5e-5](#) deg /yr.

- ▷ **3** *Plotting and drawing a subset* – This fairly certainly corresponds to the Pleiades. TOPCAT has the notion of *subsets*, i.e., parts of whole datasets defined in various ways. One way to define such a subset is by freehand selection, which is appropriate here.

To define a subset in this way, use [Subsets](#) → [Draw Subset region](#). Now

draw a region around the overdensity in PM space. When finished with that, go to [Subsets](#) → [Finish Drawing region](#). In the window popping up in response, in **New Subset Name** enter something like “Pleiades candidates” (it doesn’t really matter), and click on [Add Subset](#). You will now see the subset in a different colour on the plot than the other objects.

In each plot of this dataset, you can now restrict display to only this subset in the [Subsets](#) tab in the lower part of the plot window. For this plot, that is somewhat pointless, but wait on.

- ▷ **4** *Defining a colour* – A plot in which the subset makes a lot of sense is a colour-magnitude diagram (CMD), where a colour, as is custom in astronomy, simply is the difference of magnitudes in two different bands.

There are several different ways you can introduce such colors (or other derived quantities) into TOPCAT tables. One is giving them directly in the plotting window. So, go back to the tab [Position](#) and as **X:** axis enter `phot_g_mean_mag-phot_rp_mean_mag` and as **Y:** axis enter `phot_g_mean_mag`. Eventually click on [Axes](#) and tick **Y-flip**, because we are plotting magnitudes. Again go to the subsets tab in your plot and compare the CMDs of the whole dataset and of your Pleiades subset.

- ▷ **5** *Adding columns* – Sometimes derived quantities like colours can be reused in several places. In that case, you will want to add a column containing the results of an algebraic expression. To do that, in TOPCAT’s main window go to [views](#) → [Columns info](#). In the new window we click on [Columns](#) → [New Synthetic Column](#). Here you can enter the parameters of our new column.

As an example, create a column called `g/rp`, defined by the **Expression** `phot_g_mean_mag-phot_rp_mean_mag`. With **Index**, control where the new column shall appear; use 3 here to follow this example. Click on **OK** to add the new column to the data. Return to TOPCAT’s main window and go to [Views](#) → [Table data](#) to have a look at the data. In the third position you now can see the newly added column. Don’t be confused that some data records don’t have entries in this columns – that’s simply because the same data records won’t have entries at the columns `jmag` and `hmag`. Keep the table data window open because we will need it later.

- ▷ **6** *Some words about metadata* – In the previous steps we told you what to enter in the fields of the plotting window or when we added a column. But whenever you retrieve data, you want to take a look at the metadata hopefully provided in the same process. Within the VO, standards to provide and access metadata are crucial. Let’s have a look at the metadata of our sample. In TOPCAT’s main window go to [Views](#) → [Column Info](#). Here you not only find the column names, but also descriptions, units and data formats. You can also edit the metadata by simply double clicking into the according field, which you should

do right away for the column you just created.

### 3 SAMP

- ▷ 7 *Data exchange between VO tools* – One of the VO's creeds is that no one big, monolithic client program will serve all the VO user's needs. To support a situation in which many (relatively) small tools cooperate on behalf of the user, the VO defines SAMP (Simple Application Messaging Protocol), which allows exchanging tables, positions, and much more between different applications.

We will use it to send the table data from TOPCAT to Aladin. For this, start Aladin and in the Survey menu click on [2MASS](#). Then return to the TOPCAT main window. In the bottom right you see the **SAMP** status. In the **Clients** field you should see three symbols: one for the SAMP hub, one for TOPCAT and one for Aladin. This means that these applications are ready to receive messages via the SAMP interface. We want to use this to send our Pleiades subset to Aladin.

A little way above the SAMP status row you will find **Row Subset**. Click there, and in the menu popping up select [pleiades candidates](#) (or whatever name you set for the subset). Then go to [Interop](#) → [Send table to](#) → [Aladin](#). The subset will be loaded in Aladin now. For further functionality we need to activate SAMP Actions in TOPCAT. This we do at [Views](#) → [Activation Actions](#). In the new opened window you can configure TOPCAT's SAMP Actions. Here you need to check *Send Sky Coordinates*. You may notice that TOPCAT already guessed which table rows contain the coordinates. This is possible due to the provided metadata (the buzzword here is *UCDs*).

Now go to Aladin and you will see the objects displayed on the 2MASS images. You can zoom in, and out with your mouse wheel. Select some of the objects and see that those objects are highlighted in TOPCAT's table data window.

Use this feature to at least look at some of the outliers in the Pleiades' CMD. Perhaps some of them are actually binary stars?

#### 3.1 Going on

Can you determine the parallax of the Pleiades according to Gaia? To get some perspective on this, check out Melis et al (2014).

### 4 References

Taylor, M. <http://www.star.bris.ac.uk/~mbt/topcat/#docs>

Melis, C., Reid, M. J., Mioduszewski, A. J., Stauffer, J. R., & Bower, G. C.  
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