

TOPCAT Tutorial

(developed by [TOPCAT](#)'s author Mark Taylor)

Uses [Aladin](#), [TOPCAT](#) and [SPLAT-VO](#)

Working with tables is the everyday activity of many researchers. TOPCAT does what you want with tables, and it does so closely integrated into the VO. From sorting to crossmatches, from histograms to density plots, TOPCAT is the swiss army knife of data manipulation and visualization. This tutorial will show you how you can do more with your tables and the VO using TOPCAT and it's connection to other VO tools.

Basic Usage: Tables, Data and Metadata Getting Started

- Start [TOPCAT](#) (click on a jar file), or from the command line type

```
topcat
```

or

```
java -jar topcat-full.jar
```

or maybe

```
topcat -Xmx512M
java -Xmx512M -jar topcat-full.jar
```

Control Window

- Use the Help window (). Search for a topic by entering words in the **Find** box. Other help options are in the **Help** menu. Or, read the [manual](#) from the [TOPCAT](#) web page.
- Load an example table:
 - Open load window ()
 - Use **Examples|Load Example Table** menu item (this will load e.g. 6dfgs_mini.xml.bz2; an example table for demo usage cut-down from the 6df Galaxy Survey, some values are faked!)
- Hover over toolbar buttons to see tool tips.
- Click on menu bar and move over each menu to see available options. Note that some of these appear in the toolbar and others don't.
- Examine basic table metadata in Control Window (Label, Name, Row count, Column count)
- Edit the Label

Table Views

Look at basic table data and metadata by using the items in the **Views** menu (or equivalent toolbar buttons). Choose a table with some metadata, e.g. the example table **6dfgs_mini** (from **Examples|Load Example Table** menu in Load Window). Other FITS or VOTable tables (especially from Virtual Observatory sources) may have useful metadata; ASCII and CSV tables probably will not.



Data View

- Scroll around
- Move columns by dragging on column headers
- Edit table data by double-clicking on cells
- Sort by column by right-clicking on column in the table



Table Parameters (per-table metadata)

- See metadata items.
- Click on a row to see more detail.
- Edit parameters by selecting them and changing the values in the detail panel below
- Add and remove parameters using  and .



Column Metadata

- Open data viewer window () at the same time
- Hide all columns () - see them disappear from the data viewer.
- Select ones you're interested in by clicking the checkboxes in the **Table** columns - see them reappear in the data viewer.
- Add a new column () - e.g. Name=B_R
 - o Name = B_R
 - o Expression = BMAG - RMAG
 - o Units = mag (optional)
 See the column appear in the columns window, and the data viewer.
- Edit the expression by double-clicking on it in the **Expression** column
- see all available functions in Functions → Syntax Help or press the f(x) button
- Add new sky coordinate columns ()
 - o Select input **System, Units** and coordinate **RA/Dec** columns (e.g. ICRS, degrees, RA2000, DEC2000)
 - o Select output **System** and **Units**
 - o Either accept or edit suggested output column names
 - o Click **OK**
 - o See new columns appear in Column and Data Viewer windows



Table Subsets (row selections)

Use a table with some metadata, e.g. the example table **6dfgs_mini** (from **Examples|Load Example Table** menu in Load Window).

- View existing subsets, see how many rows they contain (**Size**). These (if any) correspond to boolean (true/false) columns in the table as loaded; true values are included in the subset and false ones are not.
- Add a subset ()
 - o Fill in the **Subset Name** field (e.g. blue_objs)
 - o Fill in the **Expression** field with an expression based on column names that evaluates to true or false (e.g. BMAG - RMAG < -1)
 - o See how many objects are in it (**Size/Fraction** columns in window)
 - o Edit expression by double-clicking it
 - o Add a new subset that is the inverse of the one you've added: select its row in the display, then click .

Σ Table Statistics

- See Mean, Standard Deviation, Minimum, Maximum etc.
- Select other univariate stats from the **Display** menu
- Use the **Subset for calculations** selector at the bottom of the window to choose which subsets are calculated for

Apparent Table

- Back in the main Control Window, select a **Row Subset** which is not ALL. Note the **Rows** indicator shows Apparent rows accordingly.
- Make sure some columns are hidden in the Column Window. Note the **Columns** indicator shows Apparent columns accordingly.
- Select the **Sort Order** to sort the columns by a given column.
- Look at the table in the Data Viewer - only the selected rows and columns are there, in the selected order.
- If you Save the table now, that is what will get saved.
- Duplicate the table using the **File|Duplicate Table** menu item. This is equivalent to saving the table and reloading it. Non-apparent rows and columns have disappeared in this copy.

Load Window

- Open the **Load Window** 
- Look at the different toolbar buttons - lots of places to load a table from
- Try a normal file browser to look for tables on your local filesystem.
 - o  **Filestore Browser** usually suitable
 - o  **System Browser** may be preferred for MacOS/Windows
 - o **Format** selector:
 - **(auto)** is OK for FITS and VOTable files
 - Need to select explicitly for ASCII, CSV, etc
- Pin the window  if you don't want it to close when you've loaded a table.
- **Or**, type a URL or filename into the **Location** field, e.g.: `../data/messier.xml`
- **Or**, cut'n'paste a URL or filename onto the **Table List** in the Control Window.
- To load multiple files from the same place, pin the window open, and double-click on the ones you want.
-  Hierarchical browser can look inside tar files, zip files, Multi-Extension FITS, multi-table VOTables, etc. If you have suitable files on your disk investigate them; otherwise try the **Examples|Brows Demo Data** menu item.
-  VizieR load dialog can download data directly from VizieR.
 - o If window is too tall for your screen, resize it and use the **File|Scrollable** option (present on all windows)
 - o Load a supernova catalogue:
 - Check **All Rows** radio button
 - In the Catalogue Selection section choose **By Keyword** tab
 - Enter "Asiago" in **Keywords** field
 - Click **Search Catalogues** button

- Select first row (B/sn)
- Click the **OK** button at the button
- Table loads in TOPCAT
- o Search for 2MASS extended sources:
 1. Click **Cone Selection** radio button
 2. Enter your favourite object name
 3. Click **Resolve** to get coordinates - **RA** and **Dec** fields are filled in
 4. Enter a suitable radius (1 degree?) make sure units selector is set correctly
 5. Click **Surveys** in catalog selection below
 6. Select 2MASX (The 2MASS Extended Source Catalogue) and click **OK**
 7. Table loads in [TOPCAT](#)

[[ Millennium simulation database query.

- o Default URL is for public database, no password required
- o Choose Millenium from Base URL selector (MyMillennium3 requires password)
- o Use one of the examples in the **HaloSamples** or **GalaxySamples** (in the top menu bar), an example SQL query appears, click **OK**
- o ... or enter your own SQL.]]

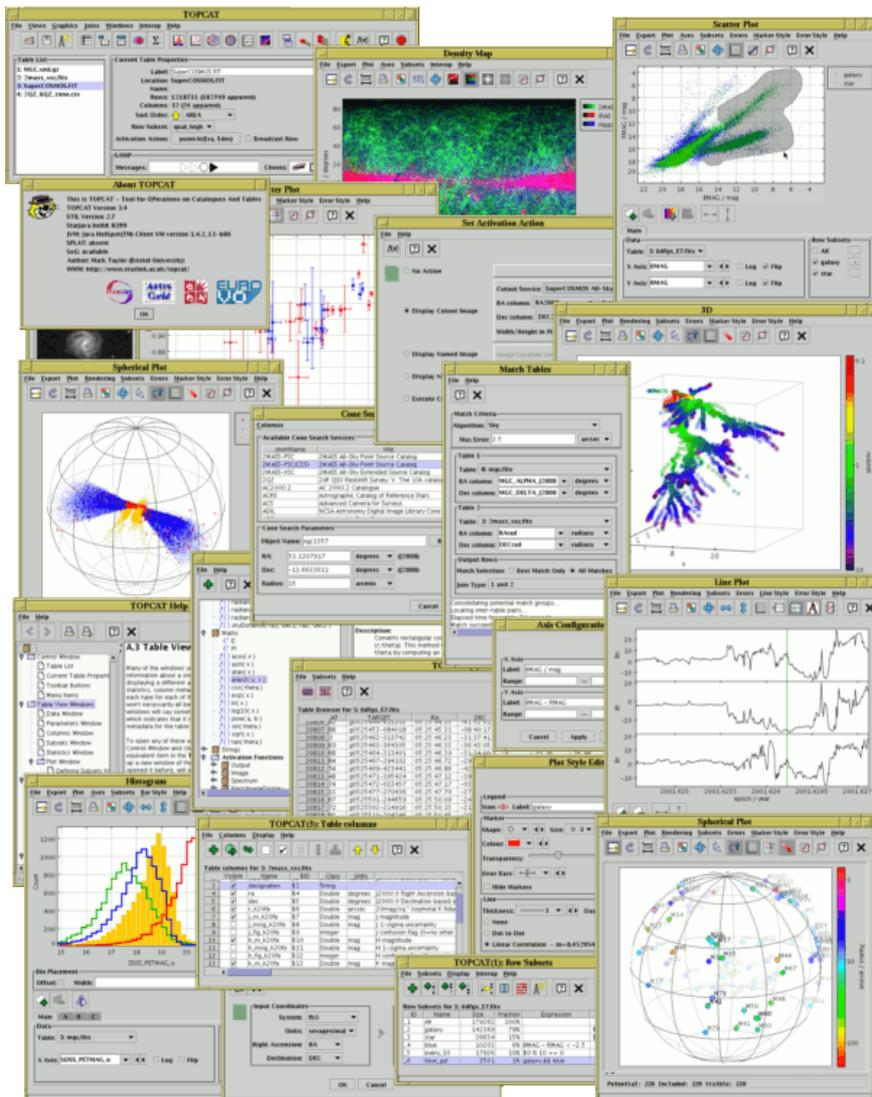
Save Window

- Select a table in the Control Window table list, open save window 
- Use **Filestore Browser**  or **System Browser**  to save it.
- Choose an output format:
 - o If in doubt, choose FITS (most efficient, stores metadata)
 - o ASCII/CSV is OK if you want to process with other software
 - o Various other options are available ... see the [manual](#) for details
 - o TOPCAT will choose a sensible format if you use a well-known file extension like ".fits", ".csv", ".txt"
 - o save one of the above tables as text table, ascii or csv format
- To save multiple tables in one file, use **Multiple Tables** tab (FITS/VOTable only)
- To save session, use **Save Session** tab; this saves subsets and hidden columns, not just apparent tables

Plotting

- Open Scatter Plot 
- Do a colour-magnitude plot for table 6dfgs_mini:
 - o **X Axis** BMAG-RMAG, **Y Axis** RMAG, select **Flip** checkbox for Y axis.
 - o Plot and unplot different subsets by ticking the **Row Subsets** in plot window
 - o Use different plotting styles (click on plot symbols in **Row Subsets** panel, and/or **Marker Style** menu)
 - o Add error bars ( and/or , or **Errors** menu)
 - o Change error styles (click on plot symbols in **Row Subsets** panel, and/or **Error Style** menu)

- o Make a new subset by selecting some of the points in the plot (click ; drag out a region or regions, click  again)
- o Experiment with Auxiliary Axes ()
- o Try adding text labels ()
- o Try the other plot types and options therein; some example tables are [here](#).
 -  histogram (try weighting values )
 -  Cartesian 3d plot
 -  Spherical 3d plot (try adding radial coords )
 -  Stacked line plot
 -  Density plot (needs a large data set)
 - save some of the plots as pdf, gif or fits (density plot)



Exercise 1: Add metadata to table

This exercise shows how to load a text table into [TOPCAT](#), add column names and descriptions and table parameters, and to save it as a FITS file:

[TOPCAT](#) has two main text-based formats for tables:

- ASCII (see [ASCII file details](#)); don't forget to select **ASCII** format when loading it.
- Comma-Separated Values (see [CSV file details](#)); don't forget to select **CSV** format when loading it.

If you strip out all the column headings, you should be able to load the table, but it will have column names like "col1", "col2" etc.

Use the ASCII file [extracted.txt](#), or one of your own.

- Load the table  selecting **Table Format** as "ASCII" (or "CSV" if appropriate)
- Check the column data types look OK (**Class** column in Columns window ) , e.g. numeric columns should not have String type
- Make sure the columns have sensible names. Either:
 - Edit the column names by double-clicking on them in the Columns window 
 - **Or:** add a new header line in the ASCII file before loading it
- Add some units and/or descriptions in the Columns window 
- Add some per-table metadata (e.g. author, date) in the Parameters window 
- Add some more calculated columns  if you like
- Save the table as a FITS or VOTable file 
- Reload it to check that the metadata is still there present

Exercise 2: Pleiades

(Credit: Niall Deacon, Hawaii)

- Open the Vizier load dialog ()
- Search for all the objects within 3 degrees of the Pleiades in the Tycho-2 catalogue:
 - Check **Cone Selection** button
 - Object name Pleiades, **Resolve**
 - Radius 3 degrees
 - Catalogue Selection **Surveys** tab
 - Click on row Tycho-2 (Name column is ordered alphabetically)
 - Click **OK**
 - Loads 3 tables - pick the one with most rows
- Visualise proper motions:
 - Open a scatter plot window 
 - X = pmRA, Y = pmDE
 - Zoom in to find a cluster with non-zero motion

- o Draw a blob round it to create a new subset (click ; drag out the cluster region, click  again)
- Draw colour-magnitude diagram:
 - o Open a different scatter plot window 
 - o $X = VTmag - BTmag$, $Y = VTmag$, flip Y
 - o See where the new cluster subset you identified sits in colour-magnitude space (main sequence?). If there are outliers, click on them to see their location in the proper motion plot.
- Save the cluster identification:
 - o Go to the Subsets window 
 - o Select the row corresponding to the cluster subset
 - o Create a new boolean table corresponding to this subset by clicking the **To Column**  toolbar button
 - o Save the table.

Exercise 3: Pleiades revisited

Examine some other colours for the Pleiades cluster you identified in the previous exercise.

- Reload the table from the previous exercise.
- Select the cluster subset as the Current **Row Subset** in the Control Window. This will have the effect that subsequent matches only operate on these objects.
- Go back to the VizieR load window , query a catalogue with different photometry in the same region (e.g. 2MASS-PSC)
- Crossmatch the (now subsetted) Tycho-2 catalogue with this new catalogue . You probably want Algorithm **Sky** with a suitable Max Error, and Match Selection **Best Match**, but if the resolutions of the different catalogues are significantly different, some other choice might be appropriate.
- Visualise the positions of the crossmatch by overplotting the three sets of positions in the Spherical Plot window :
 1. Input cluster positions
 2. Positions loaded from VizieR catalogue(s)
 3. Results of crossmatch

Overplot multiple data sets using  use **MarkerStyle** menu to chose suitable symbol sets. Check the results look sensible.
- Using the resulting cross-matched table, do a different colour magnitude diagram  of the cluster objects. See the crossmatch objects in the main sequence.

Exercise 4: Multiple Simple Spectral Access Query

(expanded by Janine Fohlmeister)

- Get the Asiago catalogue of supernovae from the Vizier load window  - click the **All Rows** radio button, search for "supernovae asiago" in the **By Keyword** tab, select "B/sn" and hit **OK**.
- Look at the table  - observe the Type column.
- Create a new subset in the Subsets window  -
Name = 'type2', Expression = 'startswith(type, "II")'.
- Set this subset as the current **Row Subset** in the control window; this means that subsequent operations like the multi-SSA query will only operate on that subset.
- Do an SSA multicone query  from the **VO** or **Joins** menus on the main control window. Select a service (registry euro-vo.org), e.g. HST Spectra (either search by **Keywords** for "hst" or similar, or just find it in the list of services that appears automatically, perhaps by sorting the list which you can do by clicking on the appropriate column headers).
- When you've clicked the service, fill in the parameters at the bottom of the window: **Input Table** is the SN catalogue, and make sure the **RA** and **Dec** selectors are filled in appropriately. Set **Search Radius** to 100 arcsec. (in case: set **Error Handling**: ignore)
- Hit **Go** and wait (see progress at the bottom of the search window – you might get a coffee meanwhile) for it to announce that it's added a new table. This is a table of all the HST spectra for type II supernovae from the B/sn catalogue.
- Work out the age of each supernova when the spectrum was taken. Add a new column "obs_age" ( in  window) with this expression:
 $\text{mjdToDecYear}(\text{isoToMjd}(\text{obs_start_time})) - (\text{parseInt}(\text{substring}(\text{SN}, 0, 4)))$
(see the functions window  for documentation). Note however this is only approximate, since the catalogue only gives you the observational date and the year of the supernova designation.
- Therefore create a new subset with $\text{obs_age} \geq 0$. (what is the unit of obs_age?)
- Plot them on a sky plot  - colour them by age  and label them by ID, SN or target of the spectrum .
- Start up a spectrum viewer such as [SPLAT](#) (here is a link for [splat WebStart](#); for the full documentation click here).
- Make sure a SAMP hub is running . Observe in the control window that TOPCAT can see SPLAT 

- Set an Activation Action for the SN spectra table; click the **Activation Action** button in the control window, select **View URL as Spectrum**. Ensure that the **Spectrum Location Column** is filled in as the column which contains the spectrum URL (TOPCAT should fill this in automatically from examining column UTypes/UCDs - it's **AcRef** for the ST-ECF/HST/SSA service). You must then hit the **OK** button at the bottom of the window.
- Click on one of the points in the spherical plot. It will cause the corresponding spectrum to be displayed in [SPLAT](#).
- Display some of the spectra in [SPLAT](#). The names of the spectra appear under “Global list of spectra”, note that cone search gives also spectral results for host galaxies or other objects within the search radius.
- Move over each button in the menu to see available options.
- See table view  in [TOPCAT](#) for wavelength and target information.
- In [SPLAT](#) double click on a spectrum or highlight several and display them in one plot using the  button. You can change the colour and appearance of the spectra either by clicking  (random choice of colours) or modifying the **Properties of current spectra**. Click the  button to see an animation of all loaded spectra.
- For a spectrum of your choice (e.g. SN1987A) perform a polynomial line fit: click , choose the degree of the polynomial, click the **Add** button and drag the mouse in the display window to select the range you want to fit, then press **Fit**.
- The polynomial fit appears in the plot and under the **Global list** of spectra of the main [SPLAT](#) window.
- You can **Add, Subtract, Devide** or **Multiply** your spectrum with the polynomial fit by clicking the  button (try it!), this generates a new spectrum in the **Global** list.
- Fit the strongest spectral line in SN1987A using a variety of functions: in the [SPLAT](#) plot window choose , this opens the spectral lines fitting window; select the types of fits you want to perform (**Gaussian, Lorentzian, Voigt**), select the type of **Background** (either a **Constant, Polynomial**, or a loaded background spectrum), **Add** the coordinate range of the line: see the fitting parameters for the different profiles in the lower part of the window. You can save the fit results via **File** → **Save line fits**.
- Try to find line identifiers via **Options** → **Line identifiers** e.g. “SDSS_reflines”
- Print the spectra and fits of your choice as ps or jpeg.