Crossmatching with TOPCAT

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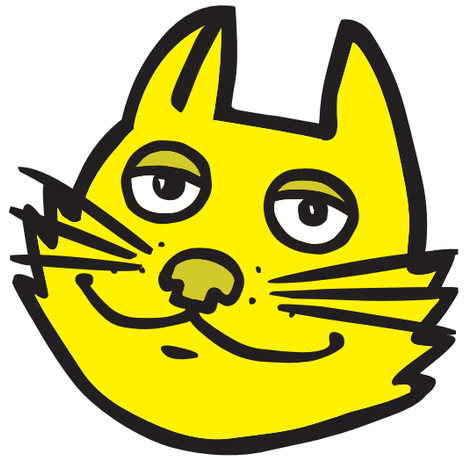

Astro Sprint Enterprise
Online seminar

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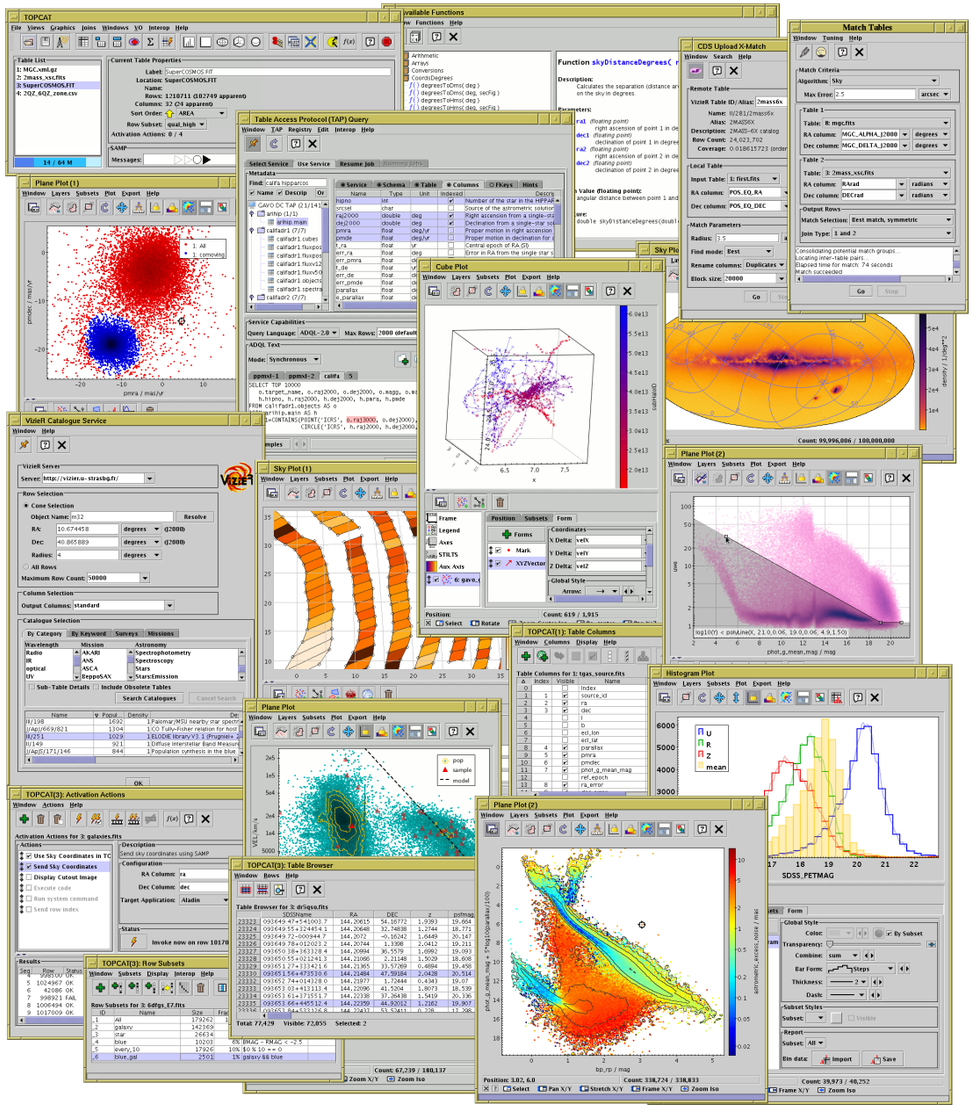
Assumed background

TOPCAT = Tool for OPerations on Catalogues And Tables

"Does what you want with tables"



This is not an introduction to TOPCAT!

It builds on my Shristi Astronomy seminar from March 2020:

- Slides: http://www.star.bris.ac.uk/~mbt/talks/shristi2020/
- Video: https://youtu.be/YBMEZyoZMKw

Outline

- Introduction to crossmatching with TOPCAT
  - Capabilities, regimes, techniques
- Demo with dataset 1: Pleiades with Gaia and 2MASS
  - Internal pair match
  - CDS X-Match window
  - TAP Upload match
- *Questions?*
- Demo with dataset 2: NGC346 with Gaia and HST
  - Ironing out problems with matching
- *Questions?*

Crossmatching

What is crossmatching:

- Identify which objects in one table correspond to which objects in another table
- ... typically in different observational regimes (e.g. wavelength)
- ... typically on basis of sky position (closest objects match)
- ... typically to combine observations, e.g. multi-wavelength photometry

TOPCAT crossmatching options:

- Provides several options for identifying "nearby" objects in two tables, multiple tables or a single table
- Various criteria for what counts as "nearby"
- Various options for what to do with matches; mostly create new table joining input tables
- (But also various things it *doesn't* do e.g. match probabilities, proper handling of differing length scales)

TOPCAT post-processing:

- Crossmatching is usually one step in a scientific workflow
- Lots of capabilities for looking at and understanding the results

Options and Regimes

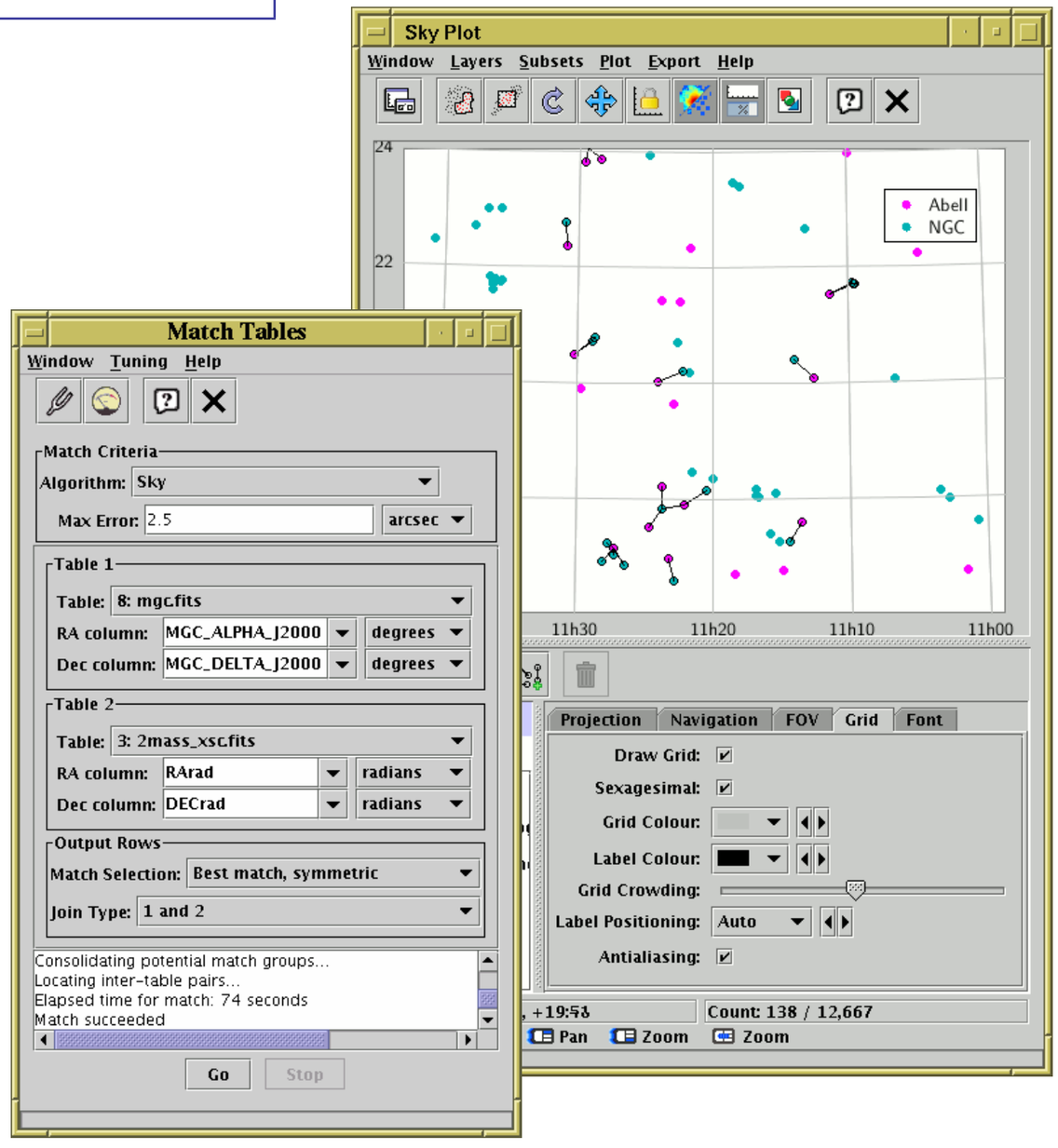
Internal Matching

- Both/all files loaded into TOPCAT
- Works well up to ∼1 million rows each
- Pretty fast (≤couple of minutes)
- Quite flexible (sky, Cartesian, exact, 3D, ellipses, errors, combinations...)
- Works for two tables, within a single table, 3, 4, 5 tables

External Matching

- One or both tables too big to download
- Several options, with different pros and cons:
  - ▷ CDS X-Match
    (any VizieR table, sky match, fast, easy)
  - ▷ Multiple cone search
    (many tables available, sky match, slow)
  - ▷ TAP
    (few tables available, flexible, tricky)

Usually Internal Matching is better/easier if tables are small enough



Demo 1: Gaia vs 2MASS Pleiades

Gaia data from GAVO DC TAP service:

```
WITH reg AS (
    SELECT ra, dec, ra_error, dec_error, pmra, pmdec, pmra_error, pmdec_error,
           parallax, parallax_error, dr2_radial_velocity, dr2_radial_velocity_error,
           phot_g_mean_mag, phot_bp_mean_mag, phot_rp_mean_mag, phot_bp_mean_mag-phot_rp_mean_mag AS bp_rp
    FROM gaia.edr3lite
    WHERE 1=CONTAINS(POINT(ra, dec), CIRCLE(56.75, 24.1166, 3)
)
SELECT * FROM reg
WHERE SQRT(POWER((pmra - 19.7)/2.7, 2) + POWER((pmdec + 45.3)/3.1, 2)) < 1
```

2MASS data from GAVO DC TAP service:

```
SELECT RAJ2000, DEJ2000, errMaj, errMin, errPA, mainId, Jmag, Hmag, Kmag
FROM twomass.data \
WHERE 1=CONTAINS(POINT(RAJ2000,DEJ2000), CIRCLE(56.75, 24.1166, 3)
```

Demo 2: Gaia vs. HST NGC 346

Gaia data from Gaia-ARI Cone Search service:

`https://gaia.ari.uni-heidelberg.de/cone/search?ra=14.771207&dec=-72.1759&sr=0.05&verb=1`

HST data (Gouliermis et al., 2006ApJS..166..549G) from VizieR:

`http://vizier.u-strasbg.fr/viz-bin/votable?-source=J%2fApJS%2f166%2f549&-oc.form=dec&-out.meta=Dhul`
`&-c=14.771207+-72.1759&-c.rd=1.0&-out.add=_RAJ%2C_DEJ%2C_r&-out.max=100000`