

Göttingen AG Tagung 2017 GAVO Puzzler: Solution

The challenge here probably is to figure out the right query against the right service.

Here's one way, using GAVO's data center (adapting it to the official providers of Gaia data shouldn't be hard when you use your TAP client's metadata browser).

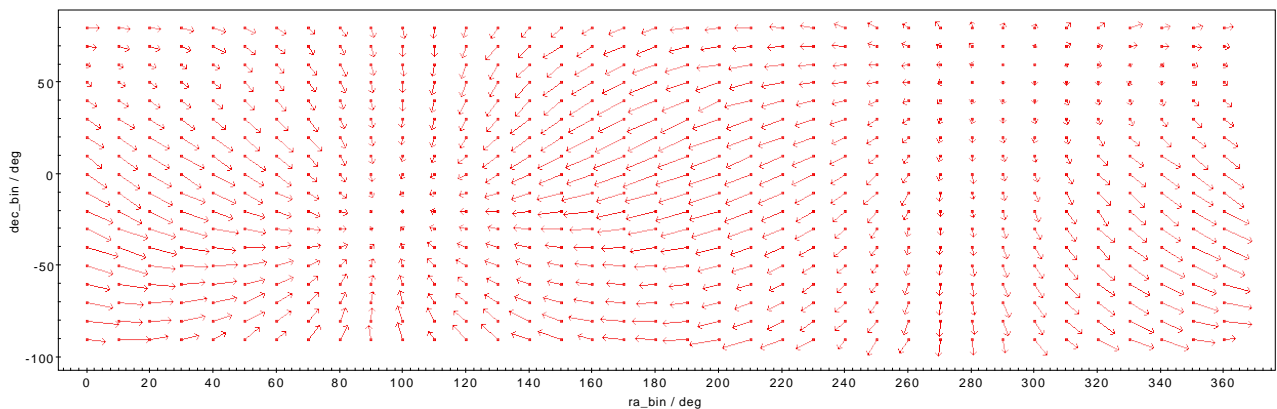
So, start TOPCAT, enter the VO/Table Access Protocol window, type TGAS into the Keywords field, and in the result, select *GAVO DC TAP*.

In the Metadata pane, type TGAS, select the *tgas.main* table, and investigate the Columns tab to get you acquainted with the data.

Then, create a suitable query; you want bins of about 10 degrees each, so strategically use *round* to create bin labels and use them in your group clause. Then, use the *AVG* aggregate function to compute mean proper motion components on each axis, and be sure to get the number of objects in each of your bins so you can get a feeling for their trustworthiness later:

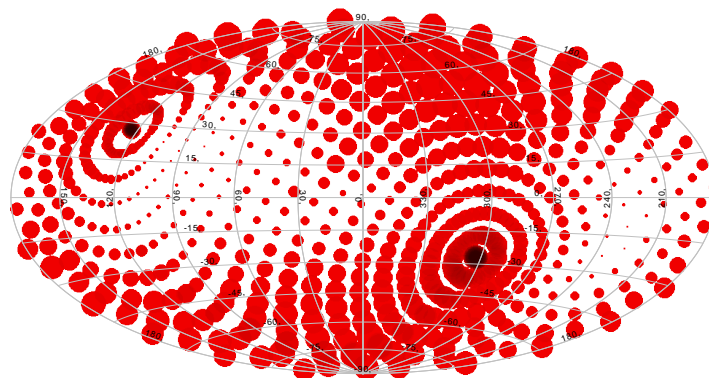
```
SELECT round(ra/10)*10 as ra_bin, round(dec/10)*10 as dec_bin,
       AVG(pmra) as pmra, AVG(pmdec) as pmdec,
       COUNT(*) as n
FROM tgas.main
GROUP by ra_bin, dec_bin
```

Now do a plane plot, and following the recipe from the hint, draw nice arrows. You should see something like this:



From this, you can see that the apex of the perceived motion would be near RA=300, Dec=60 (yes, you could probably do better than that with this data, but this isn't about statistics).

To figure out the galactic coordinates, you could either add an *AVG(l)*, *AVG(b)* to the query above and have the database add the coordinates (open a table viewer and click on points to figure out what row belongs to which point), or use TOPCAT's sky plot where, with a bit of fiddling, you get a picture like this for the absolute value of the average proper motions in a Galactic Aitoff plot:



From this, you can estimate the apex to be something like 90, 15 – which at least suggests that the Sun does have a non-negligible vertical motion out of the Galactic plane.

We have plotted absolute values here instead of arrows because the arrows would need to be transformed to Galactic too, which TOPCAT doesn't do at this point. You still see strong artefacts of the equatorial coordinates, here. If you'd rather not have these, read on.

Alternative: Use Healpixes

What's a bit ugly with this last, pedestrian solution is not only that you have massive equatorial artefacts in the last plot. Worse, the bins near the poles are much smaller than the ones at the equator – plot `n` against `dec_bin` to see what we mean.

To remedy both, group by `healpix`. This needs an extension function not available on all TAP services (called `ivo_healpix_index`), but at least the two services mentioned in the hint have it. To use `healpixes`, don't group by `ra` and `dec` separately any more but instead use a `healpix` of order, say 4:

```
SELECT avg(ra) as ra_bin, avg(dec) as dec_bin,  
       avg(l) as l_bin, avg(b) as b_bin,  
       AVG(pmra) as pmra, AVG(pmdec) as pmdec,  
       ivo_healpix_index(4, ra, dec) as hpx,  
       COUNT(*) as n  
FROM tgas.main  
GROUP by hpx
```

You'll notice that `n` is now much more evenly distributed. You can even plot directly on the `healpixes` (see the Sky Plot/Layers menu in TOPCAT). With that, the plot of the absolute value of the proper motion averages now becomes much prettier:

