

## Berlin AG Tagung 2023 GAVO Puzzler: Solution

In contrast to most previous puzzlers – for the solution of which we have nudged you towards TOPCAT – for this one we advise to use Aladin. If nothing else, it's more... well, visual.

After you have started Aladin, let's first grab our star. For that, type "Gaia DR3" into the search box ("select") below the discovery tree, and select one of the Gaia services. If you don't have preferences, go GAVO and type "Gaia DR3lite". Click on the entry below org.gavo.dc, and a dialog box will pop up. Make sure "by TAP criteria" is checked and hit "Load". The most basic ADQL is enough in the query box popping up then:

```
SELECT * FROM gaia.dr3lite WHERE source_id=4152407474508172160
```

You will get a new plane with one object. Go to that object and select a background HiPS to taste.

Let's now want to visualise the proper motion of the star. In Aladin, you – perhaps somewhat counter-intuitively – do that using the Catalog/Create a Filter menu entry. Check "Draw proper motions of stars" from the Beginner tab, but immediately switch to the "Advanced" tab to change the filter expression. We want to plot 100 times of what Aladin considers the natural length. Our star and its host cluster are about 1.5 kiloparsecs away, and so the (intrinsically) luminous star appears relatively faint and its (relatively) high proper motion isn't much on our sky. So, the filter expression would be:

```
{ draw pm($[pos.pm;pos.eq.ra]*100, $[pos.pm;pos.eq.dec]*100) }
```

When you hit "Apply", you should see a nice arrow showing our star's motion.

We are looking for NGC objects as the object's origin. The NGC is small by today's standards, so we can just pull it completely. I recommend to get OpenNGC, so type that into the "select" box. Again, select by TAP, and for simplicity, just remove the "TOP 10" from the sample query:

```
SELECT * FROM openngc.data
```

Make sure the Openngc is *below* the Filter0 plane in the Aladin's plane stack on the right – that way, the NGC proper motions are being plotted, too. Then zoom out until you see two NGC objects roughly in the direction of our star's proper motion. You will actually see two: IC 4703 and NGC 6611; both would have counted as solutions.

To estimate the age, note that the cluster has quite a proper motion, too. Extending back the two arrows until they meet (by eye is enough for our purposes) lets you measure the distance between the separation point and the current position using Aladin's dist tool, as in Fig. 1.

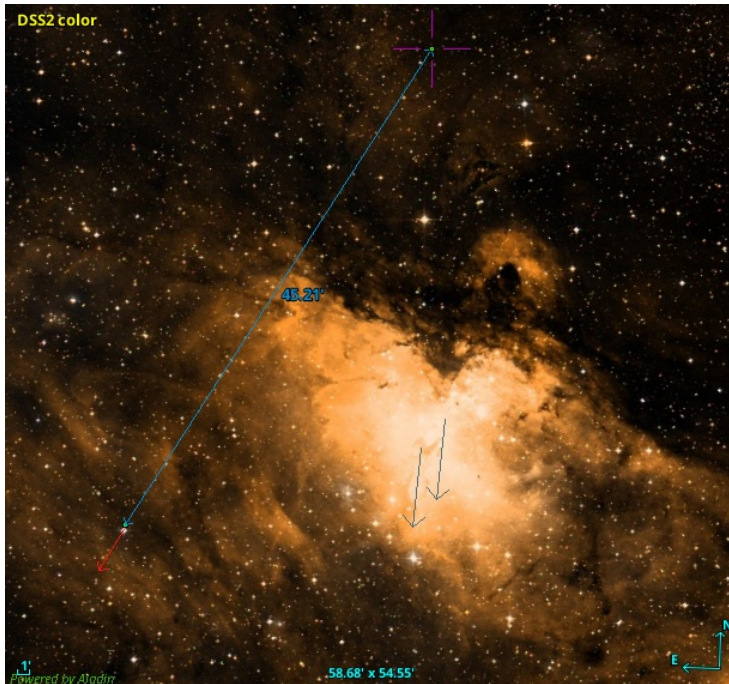


Figure 1: Aladin with filter-drawn arrows and a manual measurement to an estimated separation point.

So, the star has moved about 45 arcminutes (assuming linear motions and all) since it left the cluster, or 2.7 million mas. Meanwhile, by clicking on your initial result plane, you can find that the Gaia-measured proper motion of our star is 1.21 and -1.95 mas/yr or 2.3 mas/yr in total.

Dividing our 2.7 million mas by that gives us about 1.2 million years – not unreasonable even for an O star (as long as it's not *too* early – ours is classified as O7.5 by Stoop et al, A&A 670, A108 (2023), which by the way has been the inspiration for this puzzler).