Berlin AG Tagung 2024 GAVO Puzzler: Solution

As for most of our puzzlers, our advice is to solve the problem using TAP and ADQL, and to use TOPCAT as a client (where you will find the TAP client in the VO menu).

Once in TOPCAT's TAP window, find a server that offers the 2MASS extended source catalogue. Looking for `2mass extended` or `2mass xsc` brings up sufficiently few matches; VizieR, for instance, has the catalogue, as has IRSA, which is what I am using here.

So, double-click on the *fp_xsc* line beneath the *IRSA TAP* heading. On a sufficiently new TOPCAT, you will end up on the right page of the metadata browser; else, type *fp_xsc* into the *Find* box and then select the *Columns* tab.

We would now like to find the column with the half-light radius in J that the puzzler is talking about. Regrettably, IRSA does not provide many UCDs (compare that with the VizieR publication, where you can sort the metadata by UCD and immediately see a reasonable number of columns with a UCD of *phys.angSize*). Crossing fingers and sorting by column name at IRSA brings up *j_r_eff*. At least there is a proper description; lesson: good metadata matters.

The first step is to select the objects in the puzzler's notion of the Virgo cluster's centre, i.e., a one-degree circle around M87. If you are only an occasional ADQL user (and hence cannot immediately remember the cone selection pattern), use *Cone selection* from TOPCAT's *Basic* submenu on the *Examples* button. A quick way to resolve M87 to a position is to quickly switch into the SCS window, type "M87" into *Object Name* and hit *Resolve*.

Fixing the generated query to use the position obtained in this or some other way, and replacing the "*" (which is rarely a good idea in ADQL) to the *j_r_eff* we want results in

```
SELECT TOP 1000
       j_r_eff
FROM fp_xsc
WHERE 1=CONTAINS(POINT('ICRS', ra, dec),
                 CIRCLE('ICRS', 187.71, 12.39, 1))
```

If you run this, you will get back about 250 radii. Have a look at *Views* → *Column info* to ascertain that the radii are in arcsec, which matters because you will have to convert them to degrees to end up in areas in square degrees. To compute the (idealised) areas of these objects, you *could* write

```
SELECT TOP 1000
       area(circle('icrs', 0, 0, 4*j_r_eff/3600)) as ar
FROM fp_xsc
WHERE 1=CONTAINS(POINT('ICRS', ra, dec),
                 CIRCLE('ICRS', 187.71, 12.39, 1))
```

which should compute a spherically-precise area. However, this is broken on both IRSA and VizieR for different reasons. So, do as the puzzler tells you and use πr^2, where r is four times the half-light radius, and again make sure you get square *degrees*.

This would yield

```
SELECT TOP 1000
       3.14159*power(j_r_eff/3600*4, 2) as ar
FROM fp_xsc
WHERE 1=CONTAINS(POINT('ICRS', ra, dec),
                 CIRCLE('ICRS', 187.71, 12.39, 1))
```

Now, ignoring overlaps (if you really worry about those, you will need to employ MOCs[1], which are not available on IRSA's TAP service yet), the total area can be computed using the SUM aggegate function. Finally, divide by the total area given in the puzzler:

```
SELECT TOP 1000
       sum(3.14159*power(j_r_eff/3600*4, 2))/3.1415 as rel
FROM fp_xsc
WHERE 1=CONTAINS(POINT('ICRS', ra, dec),
                 CIRCLE('ICRS', 187.71, 12.39, 1))
```

This is 0.016: less than 2%. I had frankly expected *much* more. For comparison, in a 2 degree radius – to compute the area, you could use something like

```
select top 1 area(circle(0, 0, 2)) from tap_schema.tables
```

on a sufficiently capable TAP server like the one at http://dc.g-vo.org/tap –, it's 1.7%, within four degrees, 1.2%, within eight degrees, 0.7%. In K for one degree, it's 1.5%, with the 20 $\mathrm{mag}/\mathrm{deg}^2$ isophotal radius, we're down to less than 0.2%. Galaxy clusters are surprisingly transparent in the infrared.

[1] cf. https://blog.g-vo.org/crazy-shapes-in-tap.html