Imaging Open Clusters

Finding suitable open clusters for robotic telescopes

Metadata

General Info

Title: Imaging Open Clusters

Short description: Students investigate a catalogue of relatively unstudied open clusters in our Galaxy to find appropriate targets to observe with the

Faulkes Telescope Project telescopes

Keywords: Telescopes, open clusters, life cycle of stars, celestial coordinates

Educational Context

Context

Students learn about open clusters in our Galaxy. By examining this list, suitable targets can be found and then imaged using the Faulkes Telescope Project's access to the Las Cumbres Observatory's robotic telescopes.

Age: 15-18 years

Prerequisites

Lv. Of difficulty

Aggregation Level

Duration
2-3 hours

Orienting - Understanding Open Clusters and Their Link to the Life Cycle of Stars

Figure 1: The open cluster M25 (Credit: Jean-Charles Cuillandre (CFHT) & Giovanni Anselmi (Coelum Astronomia), Hawaiian Starlight)

One really useful set of targets from robotic telescopes are open clusters. These are loosely gravitationally bound collections of tens to hundreds of stars, all of which were born in the same initial, interstellar cloud of gas and dust (see Figure 1). This common birthplace means that they have similar chemical compositions and are at a similar distance from us, meaning that we can use their properties (brightness, colour, mass) to understand more about stellar evolution.

In our Galaxy, the Milky Way, there are approximately 1500 open clusters, of which 600 are not very well studied. This activity allows teachers and students to select suitable targets from those 600 open clusters, based on factors such as the time of year, the telescope(s) available to them, etc.

A catalogue has been produced known as the Dias catalogue (based on studies led by Brazilian astronomer, Wilton S. Dias) which provides details on each of these open clusters. These details, such as the Right Ascension (RA) and declination (dec) which combine to form its celestial coordinates and cluster size, can be used to determine which are appropriate for telescopes within the LCO telescope network.

By taking one image each in the B (blue) and V (green) filters, it is possible to construct what is known as a Colour-Magnitude Diagram (CMD). These are the observational equivalent of the theoretical Hertzsprung-Russell Diagram (HRD) which is considered amongst the most important diagrams in astronomy and astrophysics.

With the aid of a robotic telescope, such as one accessed via the Faulkes Telescope Project, you could take some images of an open cluster and create your own diagrams for these unstudied objects.

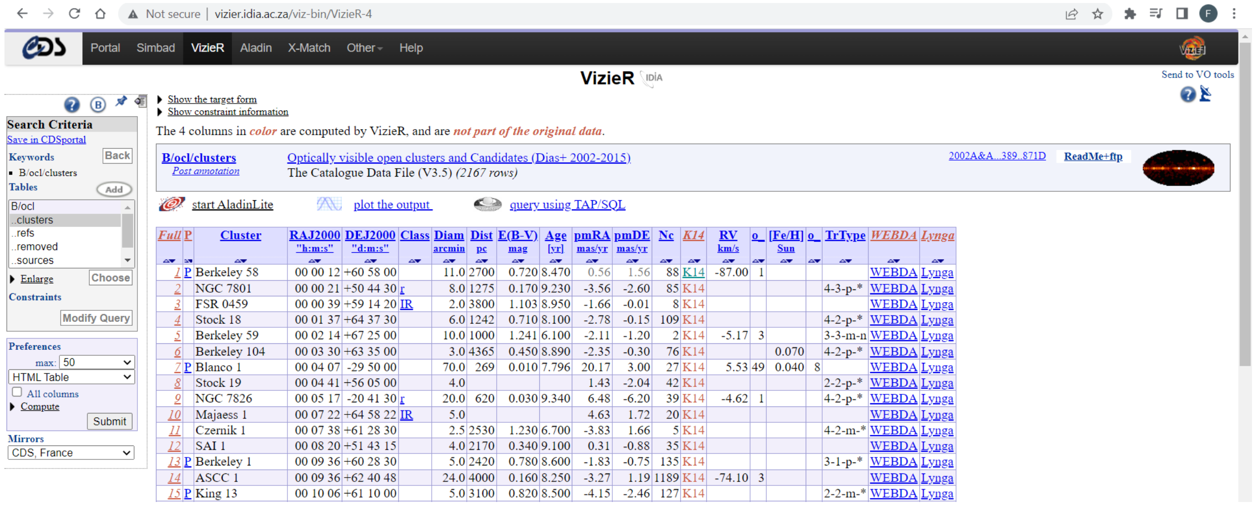
Hypothesis Generation and Design - Finding a Target

In this activity you will explore some online databases to find a suitable target. But what do we need to consider when finding a target? Take some time to think about possible questions and how this may form a hypothesis. Some example questions are given below:

- What size of open cluster might we want to observe ?
- How bright does it need to be for us to observe it properly with our telescopes?
- How might we go about deciding if the target is currently visible?

Catalogues such as the Dias catalogue for open clusters are very often stored online at a website called Vizier and in fact, you can go directly to the Dias catalogue here. Initially, this page looks very complicated but it is really just a set of filters that you can apply to fine-tune results from the full database. You can just start by clicking the ‘Submit’ button toward the top right of the webpage and you will see all the catalogue entries (as of September 2022, there are

~ 2100 entries; but being an online catalogue, it can be updated easily as new data are added) with the top 15 shown in Figure 2.



The 4 columns in color are computed by VizieR, and are not part of the original data.

B/ocl/clusters — Optically visible open clusters and Candidates (Dias+ 2002-2015) — The Catalogue Data File (V3.5) (2167 rows)

Full	P	Cluster	RAJ2000 "h:m:s"	DEJ2000 "d:m:s"	Class	Diam arcmin	Dist pc	E(B-V) mag	Age [yr]	pmRA mas/yr	pmDE mas/yr	Nc	K14	RV km/s	o_	[Fe/H] Sun	o_	TrType	WEBDA	Lynga
1	P	Berkeley 58	00 00 12	+60 58 00		11.0	2700	0.720	8.470	0.56	1.56	88	K14	-87.00	1				WEBDA	Lynga
2		NGC 7801	00 00 21	+50 44 30	r	8.0	1275	0.170	9.230	-3.56	-2.60	85	K14					4-3-p-*	WEBDA	Lynga
3		FSR 0459	00 00 39	+59 14 20	IR	2.0	3800	1.103	8.950	-1.66	-0.01	8	K14						WEBDA	Lynga
4		Stock 18	00 01 37	+64 37 30		6.0	1242	0.710	8.100	-2.78	-0.15	109	K14					4-2-p-*	WEBDA	Lynga
5		Berkeley 59	00 02 14	+67 25 00		10.0	1000	1.241	6.100	-2.11	-1.20	2	K14	-5.17	3			3-3-m-n	WEBDA	Lynga
6		Berkeley 104	00 03 30	+63 35 00		3.0	4365	0.450	8.890	-2.35	-0.30	76	K14			0.070		4-2-p-*	WEBDA	Lynga
7	P	Blanco 1	00 04 07	-29 50 00		70.0	269	0.010	7.796	20.17	3.00	27	K14	5.53	49	0.040	8		WEBDA	Lynga
8		Stock 19	00 04 41	+56 05 00		4.0				1.43	-2.04	42	K14					2-2-p-*	WEBDA	Lynga
9		NGC 7826	00 05 17	-20 41 30	r	20.0	620	0.030	9.340	6.48	-6.20	39	K14	-4.62	1			4-2-p-*	WEBDA	Lynga
10		Majaess 1	00 07 22	+64 58 22	IR	5.0				4.63	1.72	20	K14						WEBDA	Lynga
11		Czernik 1	00 07 38	+61 28 30		2.5	2530	1.230	6.700	-3.83	1.66	5	K14					4-2-m-*	WEBDA	Lynga
12		SAI 1	00 08 20	+51 43 15		4.0	2170	0.340	9.100	0.31	-0.88	35	K14						WEBDA	Lynga
13	P	Berkeley 1	00 09 36	+60 28 30		5.0	2420	0.780	8.600	-1.83	-0.75	135	K14					3-1-p-*	WEBDA	Lynga
14		ASCC 1	00 09 36	+62 40 48		24.0	4000	0.160	8.250	-3.27	1.19	1189	K14	-74.10	3				WEBDA	Lynga
15	P	King 13	00 10 06	+61 10 00		5.0	3100	0.820	8.500	-4.15	-2.46	127	K14					2-2-m-*	WEBDA	Lynga

Figure 2: Screenshot from Vizier showing the first 15 clusters found (Credit; https://vizier.cds.unistra.fr/viz-bin/VizieR)

From the catalogues, you may wish to select a suitable target based on some of the following criteria …

From Figure 2, we see that we are given the RA and dec which represent the cluster's coordinates. It may be that an observer only has access to a telescope in the northern hemisphere (for example, Skinakas Observatory in Crete) and therefore might want to only see clusters visible to them. They may decide that they wish to display only those clusters with a declination of > 0 degrees. We can do this by typing '>0' in the Search box marked 'DEJ2000'.

Because of the Earth's annual orbit around the Sun, objects can be hidden from view for a few months or so per year. We suggest you use Stellarium to check that your intended target is visible. For example, in September, only objects with RA between 17 h and 5 h are easily visible (you can find this out at this weblink). We can search the catalogue on this using '<05:00:00 or >17:00:00' in the 'RAJ2000' search box. This finds clusters whose RA is less than 5 hours or greater than 17 hours.

The target (in this case, the individual stars in the cluster) needs to be bright enough to be observed by an appropriate telescope. As a rough guide, the Faulkes Telescope Project/LCO 0.4-metre telescopes are best for objects with magnitudes between 12 and 15, the 1-metre network is best between 14 and 17 magnitude and the 2-metre network is best between 16 and 19 magnitude.

Open clusters have different sizes as viewed by telescopes; some of this based on how big the cluster actually is but of course, it is also based on distance to the cluster. Those that are far away simply appear smaller to us and our telescopes. The smaller aperture telescopes within the LCO network are perhaps better suited to these objects. For example, the field of view (the area of sky the telescope can image in one go) of the 0.4-metre telescopes is 29' x 19' (' represents arcminutes) and of the 1-metre telescopes is 26' x 26'. Both of these will allow you to observe most open clusters. This however contrasts with the 2-metre telescopes. Here, the mirror can collect more light (since the diameter and area of the telescope are bigger) but the field-of-view is only 10' x 10'. If your work is taking advantage of the 2-metre telescopes, you could choose to search Vizier with the criteria '<10' in the 'Diam' field.

Planning and Investigating - Making Compromises

It may be that no single target exactly fulfils all your criteria - at this point, you'll need to behave the way a research astronomer does. Can you compromise on your needs ?

It may be that you can work with fellow students and you will come up with different targets - perhaps, based on different interpretations of what makes a good target. You could then discuss the targets' relative merits.

Once you have selected an appropriate target, you can choose to image in either real-time or queue-scheduled mode. Instructions for how to do this are included within the 'LCO Tools' link on the LaSciL Resources page.

Once you have taken your images, you can then go further and analyse them to create your own CMD, using a process known as photometry. This requires you to download some free photometry software and calculate some additional numbers using e.g. M/S Excel. Examples of how to do this are here using Makali'i and here using Salsa J.

Conclusion & Evaluation

To conclude this activity, you might want to think about how easy it was to find a single target. Does it meet all your criteria perfectly? Were there other targets that were nearly as good? If so, why did you reject these ones? Did you have to wait a few days for your 'perfect' target to appear?

Evaluation/Reflection

Comment on how well your investigation went. How accurate do you think the software is? Does it have any limitations? If you were to repeat this investigation, how would you improve it?

- Share your results with others in the class.
- Comment on any similarities/differences between your results and others.
- Think about how you individually carried out the activity and what you might change in future investigations which may affect your results.