

# Using Gaia Alerts

Finding suitable targets, such as supernovae, for robotic telescopes

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# Metadata

## *General Info*

Title: Using Gaia Alerts

Short description: Students interrogate the Gaia Alerts stream to find appropriate targets to observe with the Faulkes Telescope Project telescopes

Keywords: Telescopes, supernovae, celestial coordinates

## *Educational Context*

### Context

Students learn about the ESA Gaia satellite mission and its 'Gaia Alerts' stream which gives daily updates on astronomical objects which have changed in brightness and which may be of interest to professional and amateur astronomers. By examining this list, suitable targets (such as supernovae; exploding stars) can be found and then imaged using the Faulkes Telescope Project's access to the Las Cumbres Observatory's robotic telescopes.

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Age: 15-18 years

Prerequisites

Lv. Of difficulty

Aggregation Level

Duration

2-3 hours

# Orienting - Understanding Supernovae

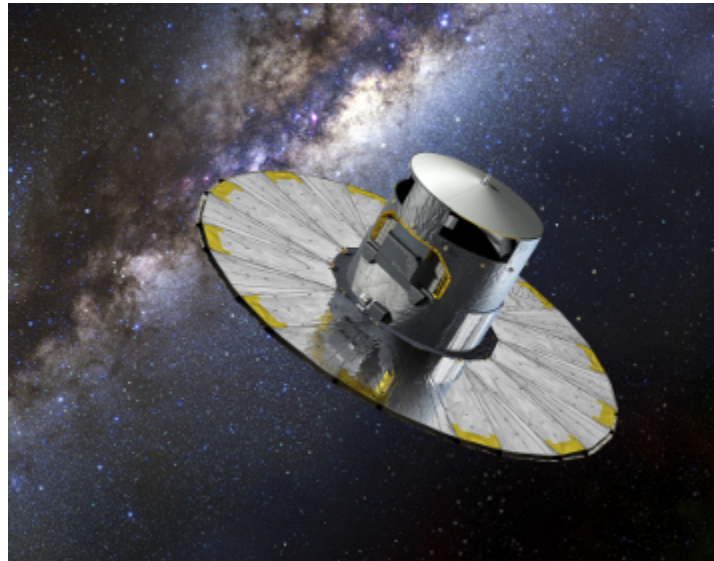


Figure 1: Artist's impression of the Gaia satellite in operation (Credit; [Wikipedia](#))

Launched in 2013, the European Space Agency currently has a mission called [Gaia](#) (see Figure 1) which is mapping the structure of the Milky Way to a previously unachievable level of precision. In fact, the Gaia mission is an amazing example of the 'big data' used in astronomy. For example, its third data release (DR3; released in June 2022) will provide unprecedented new detail for billions of stars in our Galaxy and other galaxies in the Universe (see Figure 2).

Since its method of observation is to image the same parts of our Galaxy multiple times over its mission, it has a second science aim of spotting objects that have changed in brightness since the last time they were observed. These variable objects fall into several categories such as binary stars, flare stars, variable stars (such as [Cepheid variables](#); whose behaviour help us understand the age and evolution of the Universe) and supernovae.

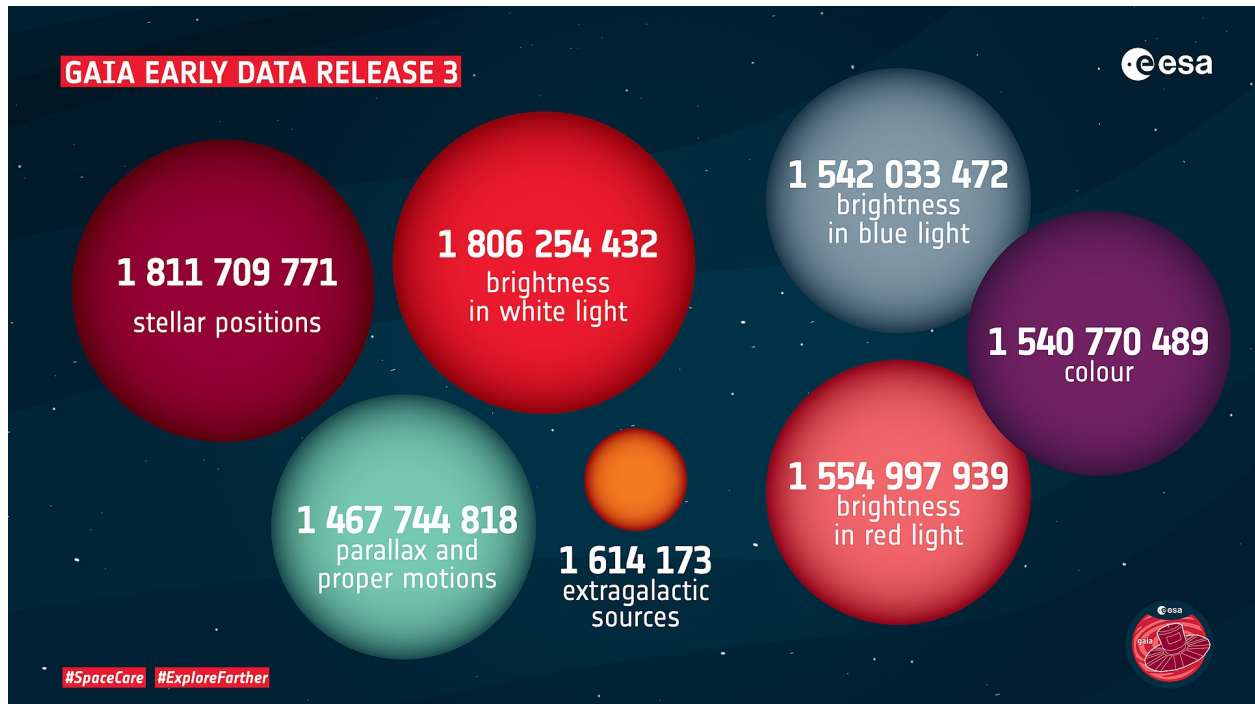


Figure 2; some facts and figures about Gaia's 2022 Data Release (Credit; [Wikipedia](https://en.wikipedia.org/wiki/Gaia_(space_observatory)))

Exploding stars, known as supernovae, are of great interest to everyone - they give us an amazing insight into how stars evolve (and die). We believe all stars which are more than 10 solar masses will end in a supernova, when all the elements they are made of are scattered back into the interstellar medium. These explosions can sometimes be so bright that the supernovae are seen by the naked eye or even (such as the one that created the [Crab Nebula](#) in 1054) in the daytime sky!

While most stars are less massive than our own Sun, there are still enough massive stars in the Universe for us to spot supernovae on a daily basis. In fact, there are rough estimates that on average, there is one supernova per galaxy per century. Based on this, it is surprising that we last detected a supernova in our own Galaxy, the Milky Way, in 1604, before the telescope was even invented.

Although most supernovae indicate the end of a massive star's lifetime, there is one exception to this. A special type of supernova (known as Type Ia supernovae) is the result of a different set of circumstances. In this case, a compact object known as a [white dwarf](#) exists in a binary system of two stars orbiting a common centre of mass. It is possible that the white dwarf can draw material onto its surface from its companion and if its mass approaches 1.44 solar masses (known as the Chandrasekhar limit), it becomes so unstable that it can no longer survive and explodes in a supernova. Since each of these explosions is believed to occur only when the white dwarf reaches 1.44 solar masses, these explosions are theorised to each be of the same intrinsic brightness. We can use this idea to develop an idea that these supernovae are 'standard candles' and that they will only differ in brightness as seen by our telescopes based on the distance to the galaxy. This then allows us to measure the distance to their host galaxies.

In turn, this allows us to explore an aspect of what is known as cosmology; we can investigate how the Universe has evolved. You can read more about supernovae [here](#).



Figure 3: Artist's Impression of the supernova, SN2016aps  
Credit: M. Weiss

With the aid of a robotic telescope, such as one accessed via the [Faulkes Telescope Project](#), you could take several images of a supernova - perhaps one image every two or three days - which will help you build-up a light-curve which shows how your object changes in brightness over time.

This activity demonstrates how we can use the [Gaia Alerts](#) web page (see Figure 4) to find a suitable target. This webpage shows us (without requiring a password or registration) a list of all Gaia Alerts, with the most recent shown at the top. Of course, we know that as with all spacecraft, Gaia will have a limited lifetime (currently planned to be in 2025) but the [Rubin Observatory's LSST](#) (Legacy Survey of Space and Time), based in northern Chile, will provide similar sets of targets from 2023 onward.

# Hypothesis Generation and Design

## - Finding a Target

Gaia Alerts Alerts Index All-Sky Alerts Search GaiaX Test Surveys-ATels Tools Documentation About Log in												
Index to Gaia Photometric Alerts												
<p>If you publish any results based on these Gaia discoveries, we would appreciate an acknowledgement along the lines of: "We acknowledge ESA Gaia, DPAC and the Photometric Science Alerts Team (<a href="http://gsaweb.ast.cam.ac.uk/alerts">http://gsaweb.ast.cam.ac.uk/alerts</a>)"</p> <p>These are all the alerts raised to date. You might wish to view or download these as a table in <a href="#">CSV</a> or <a href="#">pipe-delimited</a> formats or using the tools described in <a href="#">this page</a>.</p> <p>See <a href="#">here</a> for an explanation of the columns.</p> <p>Show 10 entries Search:</p>												
Name	TNS	Observed	RA (deg.)	Dec. (deg.)	Mag.	Historic mag.	Historic scatter	Class	Published	Comment	RVS	
Gaia22bww	AT2022ken	2022-04-26 06:55:46	137.51722	9.43495	18.28	19.39	0.21	AGN	2022-05-20 10:10:29	1 mag brightening in a known Seyfert 1 galaxy		
Gaia22bww	SN2022gor	2022-04-26 02:15:12	151.13494	-16.77367	18.56			SN Ia	2022-05-20 10:10:25	confirmed SN Ia		
Gaia22bww	SN2022ine	2022-04-25 23:34:36	318.44590	-5.81776	18.48			SN Ia	2022-05-20 10:10:17	confirmed SN Ia		
Gaia22bww	AT2022kem	2022-04-24 06:10:47	156.79034	-33.63767	18.83			unknown	2022-05-20 10:10:11	candidate SN in galaxy WISEA J102709.66-333813.3		
Gaia22bww	SN2022hua	2022-04-26 01:10:46	127.77607	23.79698	18.63			SN Ia	2022-05-20 10:10:04	confirmed SN Ia		
Gaia22bww	AT2018kkz	2022-04-25 19:43:51	96.71463	52.12913	18.04	19.18	0.39	unknown	2022-05-19 18:15:29	outburst in known candidate CV		
Gaia22bww	AT2022kdl	2022-04-04 15:43:40	59.76104	60.08946	19.01	20.10	0.25	QSO	2022-05-19 18:14:17	1.5 mag brightening in known QSO		
Gaia22bww	AT2022kdk	2022-04-24 20:10:59	43.02127	60.40118	18.18	17.07	0.18	unknown	2022-05-19 18:12:44	-1 mag dimming in candidate YSO		
Gaia22bww	AT2022kdj	2022-04-25	241.43324	-59.93052	18.95	20.78	0.29	unknown	2022-05-19	outburst in Gaia source		

Figure 4: Screenshot from Gaia Alerts (Credit: <http://gsaweb.ast.cam.ac.uk/alerts/alertsindex>)

In this activity you are exploring the Gaia Alerts webpages 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 type of object 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?

As Figure 4 shows us, there are several parameters to this table. They are

**Name:** Gaia targets contain the discovery year (22) and then a 3 letter code (the first each year is aaa then aab, etc.)

**TNS:** The Transient Name Server also gives each target a designation such as SN (supernova) and AT (astronomical transient)

**Observed:** The date and time the object was observed by Gaia

**RA, dec:** The astronomical coordinates of the object (here given in degrees)

**Mag:** The magnitude of the object as measured by Gaia - the [magnitude system](#) is used by astronomers to understand an object's brightness. It's important to remember that this system is inverted; lower numbers are brighter than higher ones.

**Historic Mag:** For objects that have been previously imaged, a historic magnitude is given to give an idea of how bright the object is normally (before it attracted the attention of Gaia).

**Historic scatter:** This is a measure of how much the object has been observed to change; which gives us an idea of how 'significant' its current magnitude is (i.e. is it behaving reasonably normally or is something 'interesting' happening?)

**Class:** This is a preliminary classification of the object ('SN' denotes supernova)

**Published:** This is the date that the Alert appeared on the website

**Comment:** Any additional information is given here

From the Gaia Alerts stream, you may wish to select a suitable target based on some of the following criteria ...

- You may already have a target type in mind such as a supernova or more specifically, a Type Ia supernova. You'll see this listed in the 'Type' column.
- The target needs to be bright enough to be observed by an appropriate telescope. As a guide, the Faulkes Telescope Project 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.
- In the case of an object that Gaia Alerts has detected, it's best to observe the most recent ones since they are likely to still be bright enough to image. So ideally, you should choose an object toward the top of the list - perhaps discovered within the last week or so.
- Because of [Gaia's location in space](#), it can sometimes observe objects that are currently not visible from Earth. We suggest you use [Stellarium](#) to check that your intended target is visible.

## Planning and Investigating - Making Compromises

It may be that no recent target exactly fulfils these criteria - at this point, you'll need to behave the way a research astronomer does. Can you compromise on your needs ? For example, if no Type Ia supernovae are in the list, could you perform a scientific study with a different type of supernova ? Or, if you're still unsure, remember that the target list is updated daily and it could be worth being patient for a few days to see what additional targets appear.

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.

## **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 (or even longer) 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.