Gaia Science Alerts

The detection of transient astronomical objects in real-time

Not all stars emit light with a constant brightness and radiation output, many of them **change in brightness very suddenly** and often unexpectedly, over a variety of timescales. We call these objects **transients**.

Every day, the Gaia team announces several **science alerts** which indicate new discoveries of transient objects. The discoveries themselves are made in Cambridge University at the data processing centre at the Institute of Astronomy. Here, they lead the UK's involvement within the Gaia Data Processing and Analysis Consortium (DPAC).

As most transients – and indeed stars – that Gaia sees are so far away from us and appear so faint, we are unable to see them with the naked eye alone. Gaia is mapping one billion stars, whereas fewer than ten thousand stars are bright enough to be seen with just the naked eye – and most of those only with very dark sky conditions!) However, these objects can be seen from the ground by harnessing the power of **robotic telescopes** such as the Faulkes Telescopes. Gaia's science alerts (GSA) provide accessible data that **schools** and amateurs can use to make their own follow-up observations to confirm these transient objects and gather more information about their **properties and characteristics.**

What?

The main objectives of the GSA are to:

- Detect **unpredicted, sudden changes** in the brightness of objects, such as stellar outbursts or entire star explosions.
- Prompt ground-based **follow-up observations** by professional and amateur astronomers.
- Provide transient object targets to **schools** and support their involvement in Gaia science through an educational programme which includes classroom-based observing with robotic telescopes.

How?

These objectives will be achieved through the following methods:

- Publicise details of objects as soon as possible subsequent to Gaia's observation. This can be as quick as **within 24 hours** and it typically within a day or two.
- Use a combination of photometric, spectroscopic and astrometric data obtained by Gaia to provide preliminary information about the object.

- Cross-match objects with existing information and previous observations made by both Gaia and other external surveys.
- Release alerts online via the GSA webpage.

Gaia sends all the data it gathers down to Earth every day over an 8 hour period. This data is initially processed at ESA centres in Germany and Spain, where it is cross-matched with all data collected by Gaia previously. Cross-matching involves identifying and comparing multiple observations taken of the same region of the sky. If two sources are seen to be in the same position (within the uncertainty) they are considered to be the same source.

After this, every day the data - containing around **50 million objects** - are sent to the Cambridge University processing centre for further analysis. It is here that the science alerts detection system, **AlertPipe**, is based.

Triggers and Rates of Alerts

There is a vast number of different transient objects that could trigger an alert, many of which will trigger **thousands** of science alerts over the 5 year mission period. Some examples include:

Supernovae:	A stellar explosion that marks the end of a star's life. Here, the majority of the star's mass is expelled outward and a sudden increase in brightness is seen that will typically outshine the galaxy they lie in.
Gamma Ray Bursts:	The most violent eruptions seen in the Universe, they are very short-lived but will often outshine the entire galaxy they sit in.
Cataclysmic Variables:	Outbursts from a white dwarf star that is accreting mass from a companion star.
New Discoveries:	Perhaps the most exciting element of the GSA is that they could reveal new transients that have never been seen before.

Find out more details about the types of transients Gaia will see at: https://gaia.ac.uk/alerts/what-and-why

The Importance of Follow-up Observations

Many of the transient objects we're interested in are relatively short-lived. They fade gradually over time until they return to their usual brightness or disappear entirely. This is why it is important to observe the transients seen by Gaia as soon as possible. This means that their changes in brightness can be monitored over time, revealing what type of object they are, whether something already known or something entirely new.

Prompt alerts and **follow-up observations** of transients soon after they are detected by Gaia are crucial for new discoveries.

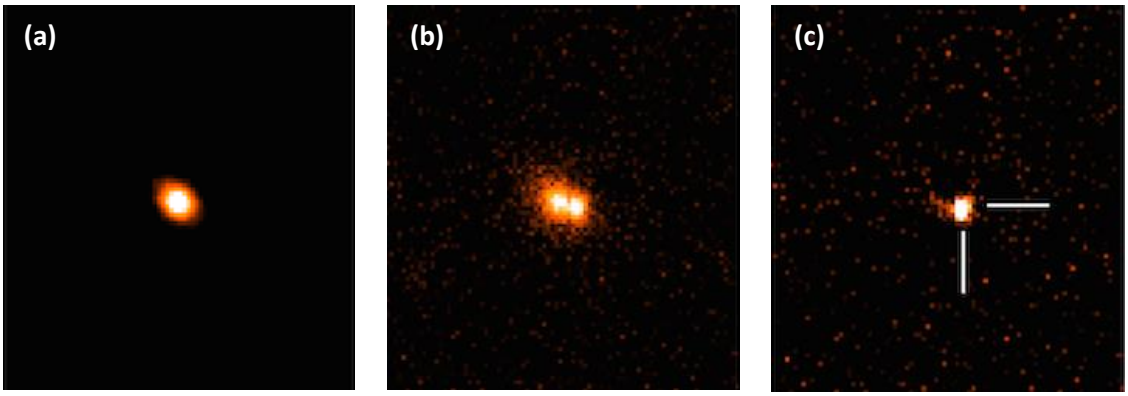
Gaia's First Supernova

On August 30, 2014, Gaia detected its first supernova, **Gaia14aaa**. This alert was triggered by a significant increase in the light coming from a galaxy around 500 million light years away. This increase was not seen to originate from the centre of the galaxy, implying that it was not associated with the galaxy's central black hole.

Follow-up observations taken with the robotic Liverpool Telescope confirmed the object that triggered the alert to be a supernova. Figure 1a shows an older image of the host galaxy, previous to the alert, Figure 1b shows an image obtained by the Liverpool Telescope on September 10 where you can see the bright supernova, slightly off-set from the host galaxy.

Figure 1c shows the result of subtracting the light in Figure 1a from that of Figure 1b revealing supernova Gaia14aaa.

Figure 1 – Gaia's first supernova, Gaia14aaa and its host galaxy. Image Credit: M. Fraser/S. Hodgkin/L. Wyrzykowski/H. Campbell/N. Blagorodnova/Z. Kostrzewa-Rutkowska/Liverpool Telescope/SDSS.



Get Involved

All of the Gaia Science Alerts are published online at: https://gaia.ac.uk/alerts/observe

Here, you will find the information you need to perform follow-up observations of transient objects. This includes the position and approximate brightness of objects.

You can find more information on how to get involved at: https://gaia.ac.uk/alerts