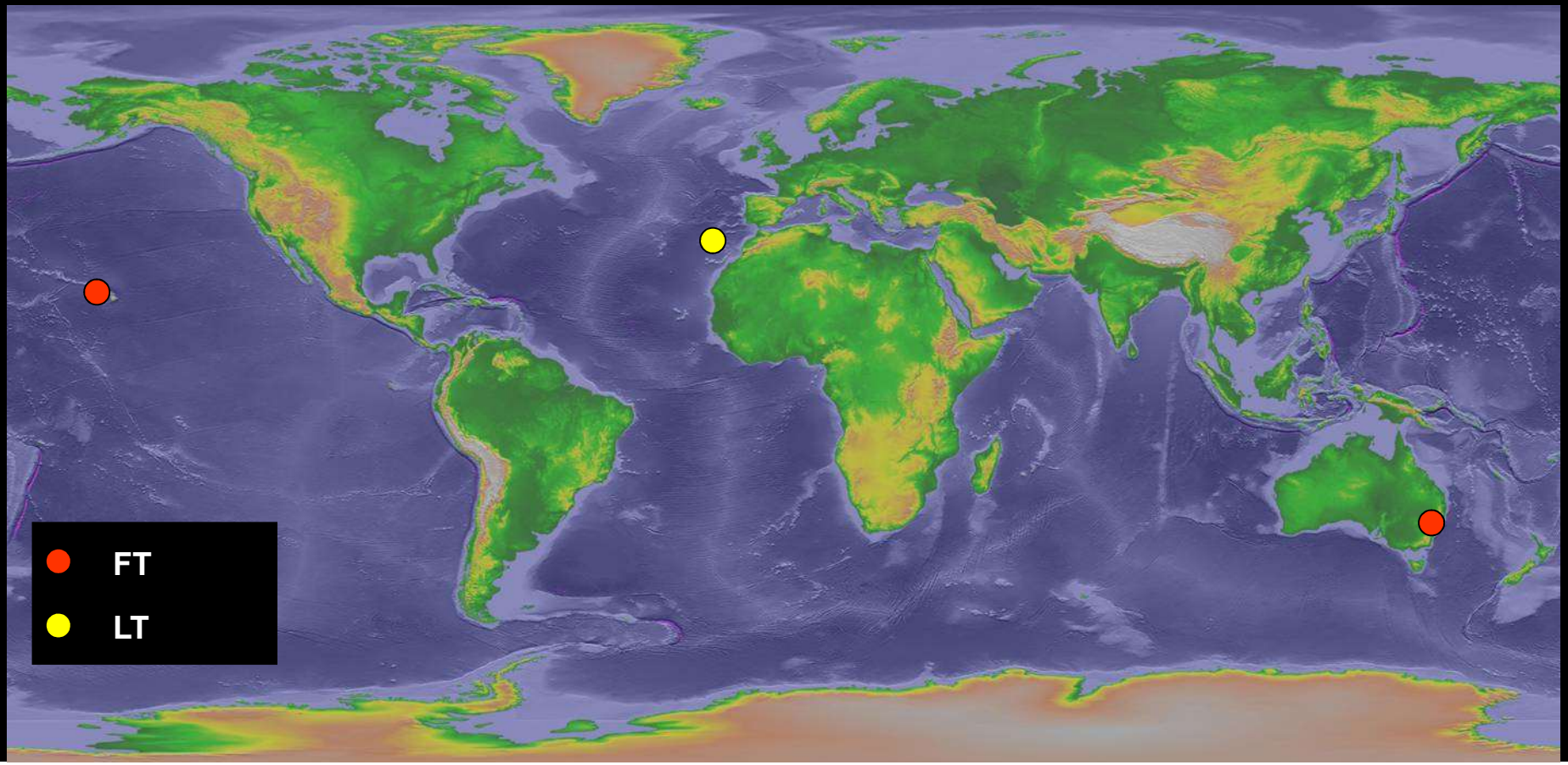
# Linking Education and Research Using Robotic Telescopes

**Fraser Lewis**
**Faulkes Telescope Project**
**National Schools' Observatory**
**Liverpool John Moores University**
**The Open University**

Robotic telescopes allow us to obtain images from (several) distant good quality sites

Only 3 * 2-metre telescopes that do this (for free !) for education - FT South & North (LCO) and Liverpool Telescope



# 2m Faulkes Telescopes

2m Richey-Cretien **f/10**

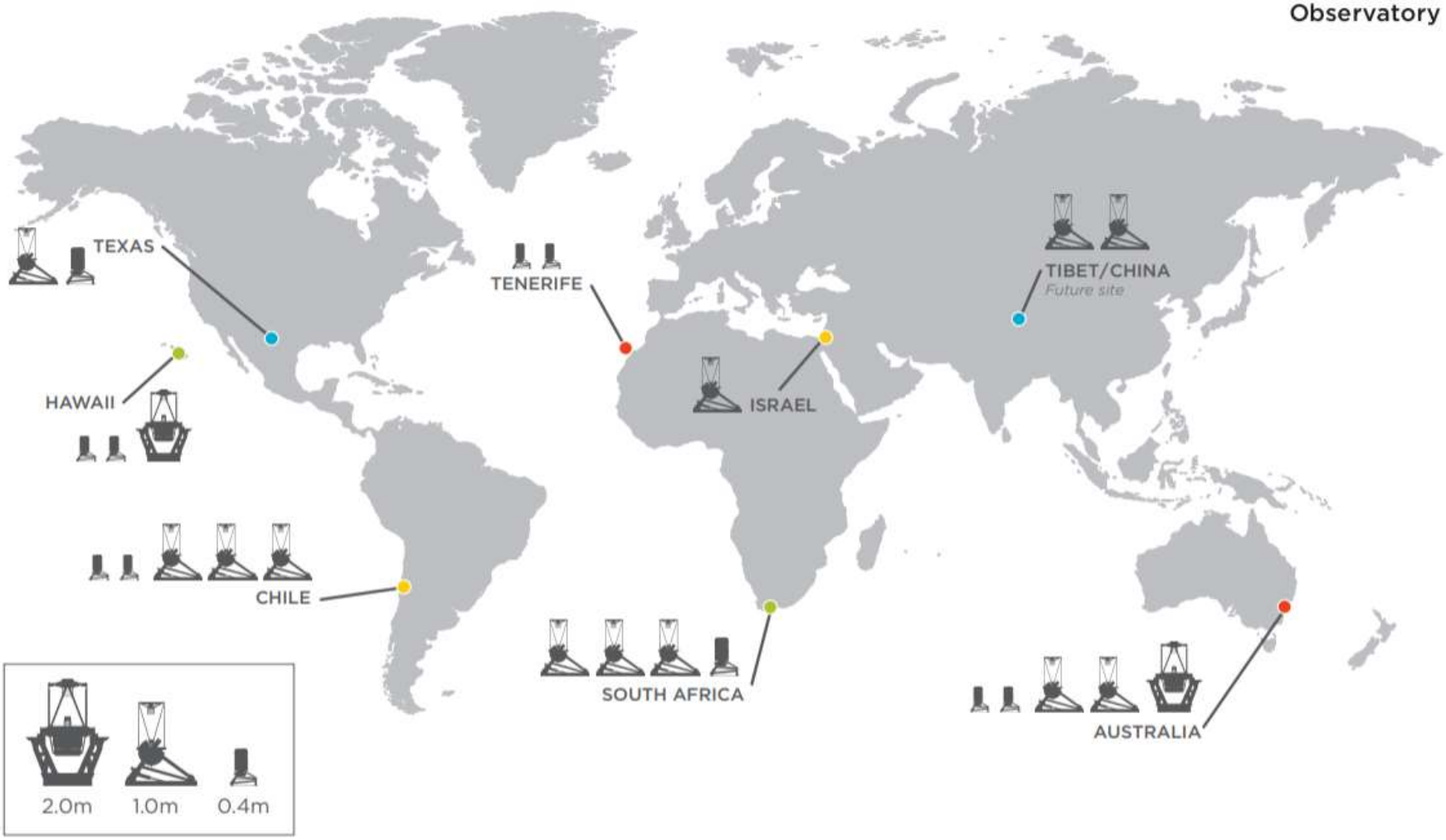
Alt/Az mount

- CCD camera (SPECTRAL; updating to MuSCAT3 – griz simultaneous)

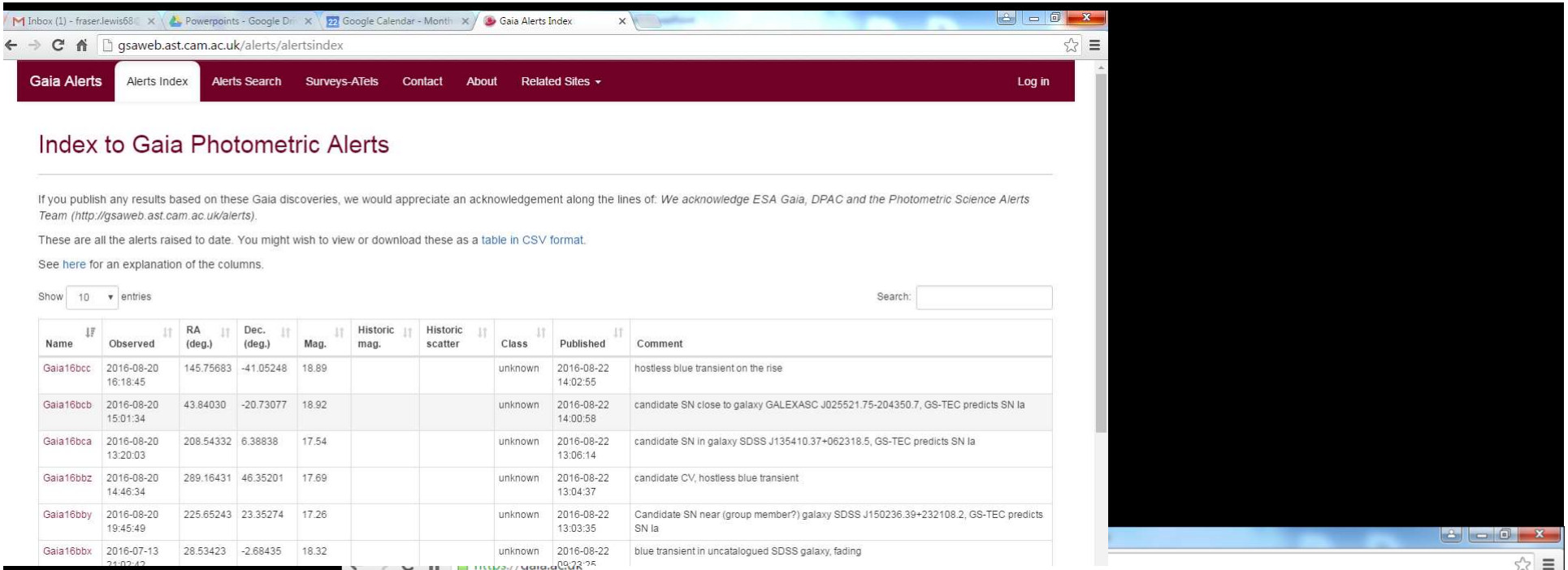
- Spectrograph (FLOYDS; R~400-700)

# GLOBAL TELESCOPE NETWORK

Las Cumbres Observatory



# Liverpool Telescope, La Palma


Gaia Alerts
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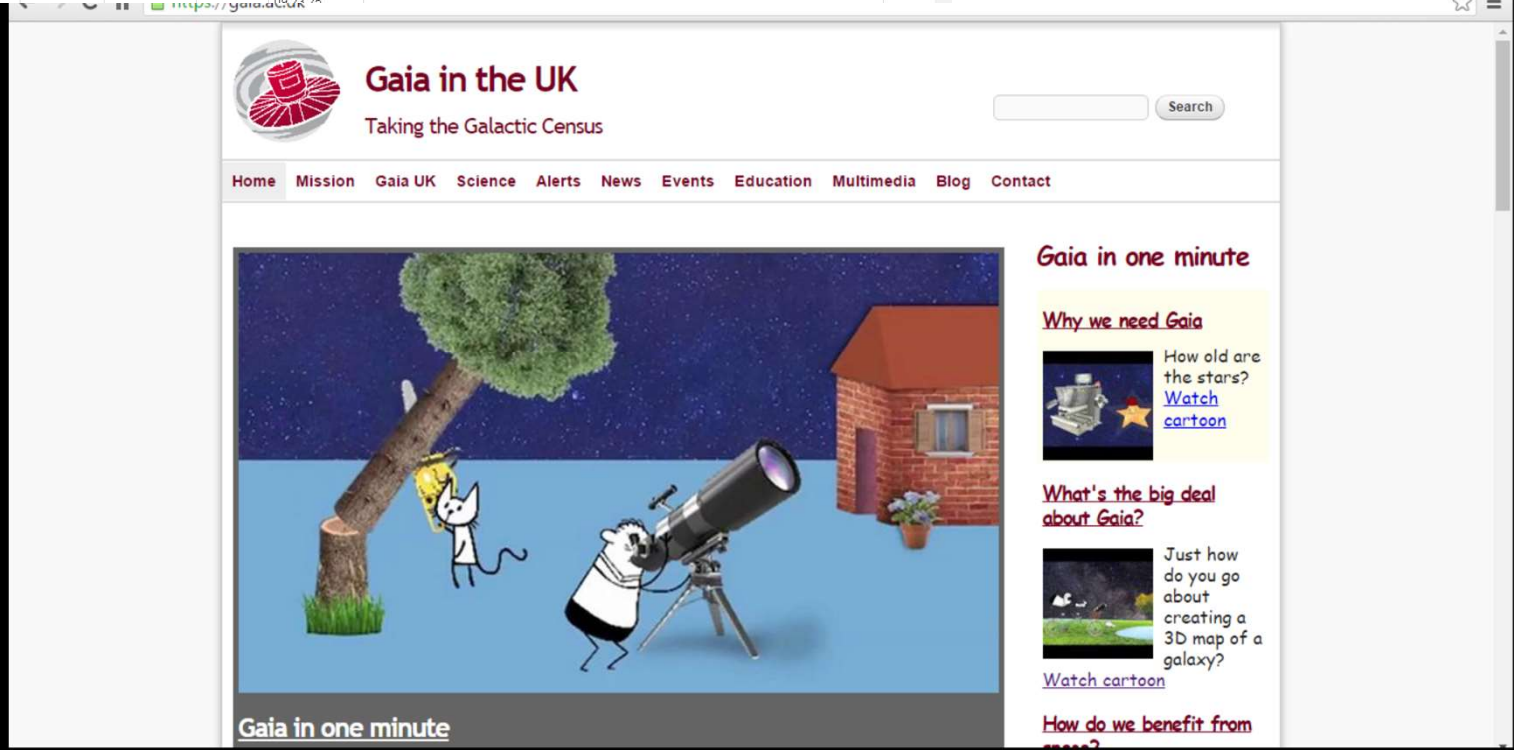
If you publish any results based on these Gaia discoveries, we would appreciate an acknowledgement along the lines of: We acknowledge ESA Gaia, DPAC and the Photometric Science Alerts Team (http://gsaweb.ast.cam.ac.uk/alerts).
These are all the alerts raised to date. You might wish to view or download these as a table in CSV format.
See here for an explanation of the columns.
Show 10 entries
Search:
Name | Observed | RA (deg.) | Dec. (deg.) | Mag. | Historic mag. | Historic scatter | Class | Published | Comment
Gaia16bcc | 2016-08-20 16:18:45 | 145.75683 | -41.05248 | 18.89 | | | unknown | 2016-08-22 14:02:55 | hostless blue transient on the rise
Gaia16bcb | 2016-08-20 15:01:34 | 43.84030 | -20.73077 | 18.92 | | | unknown | 2016-08-22 14:00:58 | candidate SN close to galaxy GALEXASC J025521.75-204350.7, GS-TEC predicts SN Ia
Gaia16bca | 2016-08-20 13:20:03 | 208.54332 | 6.38838 | 17.54 | | | unknown | 2016-08-22 13:06:14 | candidate SN in galaxy SDSS J135410.37+062318.5, GS-TEC predicts SN Ia
Gaia16bbz | 2016-08-20 14:46:34 | 289.16431 | 46.35201 | 17.69 | | | unknown | 2016-08-22 13:04:37 | candidate CV, hostless blue transient
Gaia16bby | 2016-08-20 19:45:49 | 225.65243 | 23.35274 | 17.26 | | | unknown | 2016-08-22 13:03:35 | Candidate SN near (group member?) galaxy SDSS J150236.39+232108.2, GS-TEC predicts SN Ia
Gaia16bbx | 2016-07-13 | 28.53423 | -2.68435 | 18.32 | | | unknown | 2016-08-22 | blue transient in uncatalogued SDSS galaxy, fading


esa
gaia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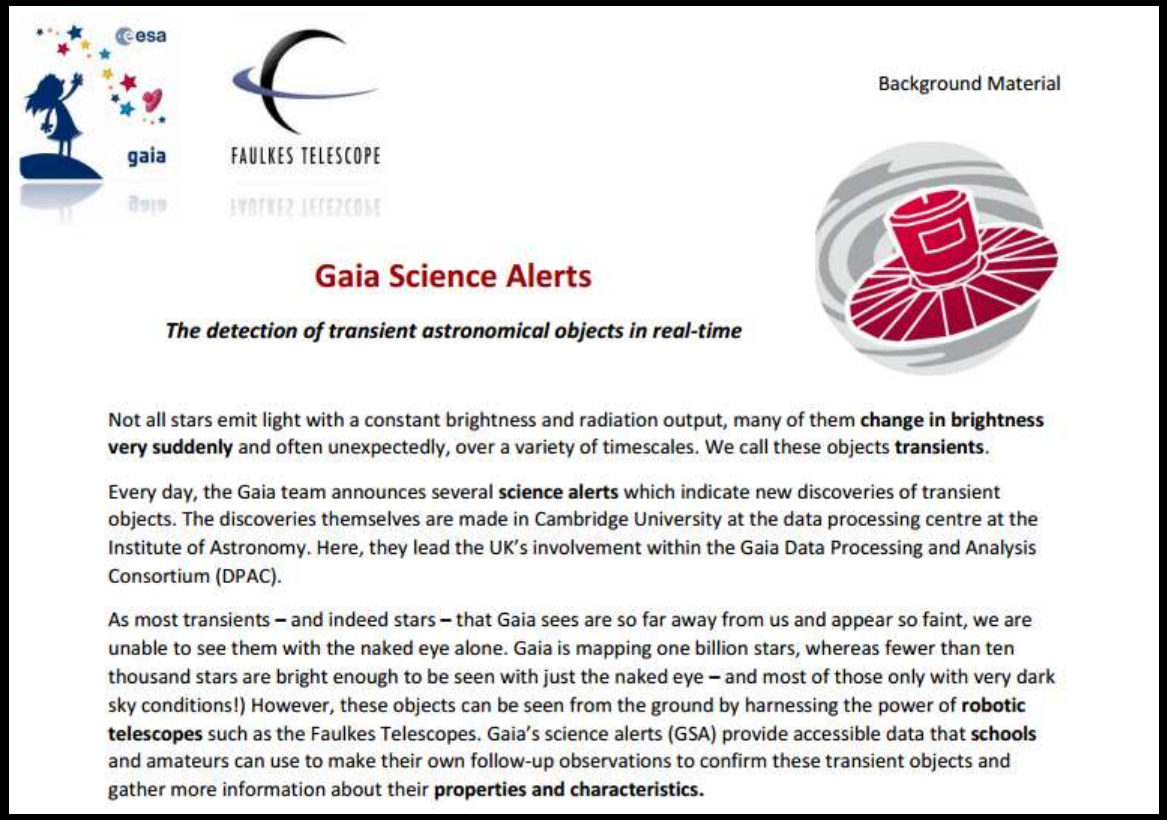
What's the big deal about Gaia?
Just how do you go about creating a 3D map of a galaxy?
Watch cartoon
How do we benefit from
Gaia in one minute

# Spotting a Supernova Worksheet



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FAULKES TELESCOPE

Background Material

## Gaia Science Alerts

***The detection of transient astronomical objects in real-time***

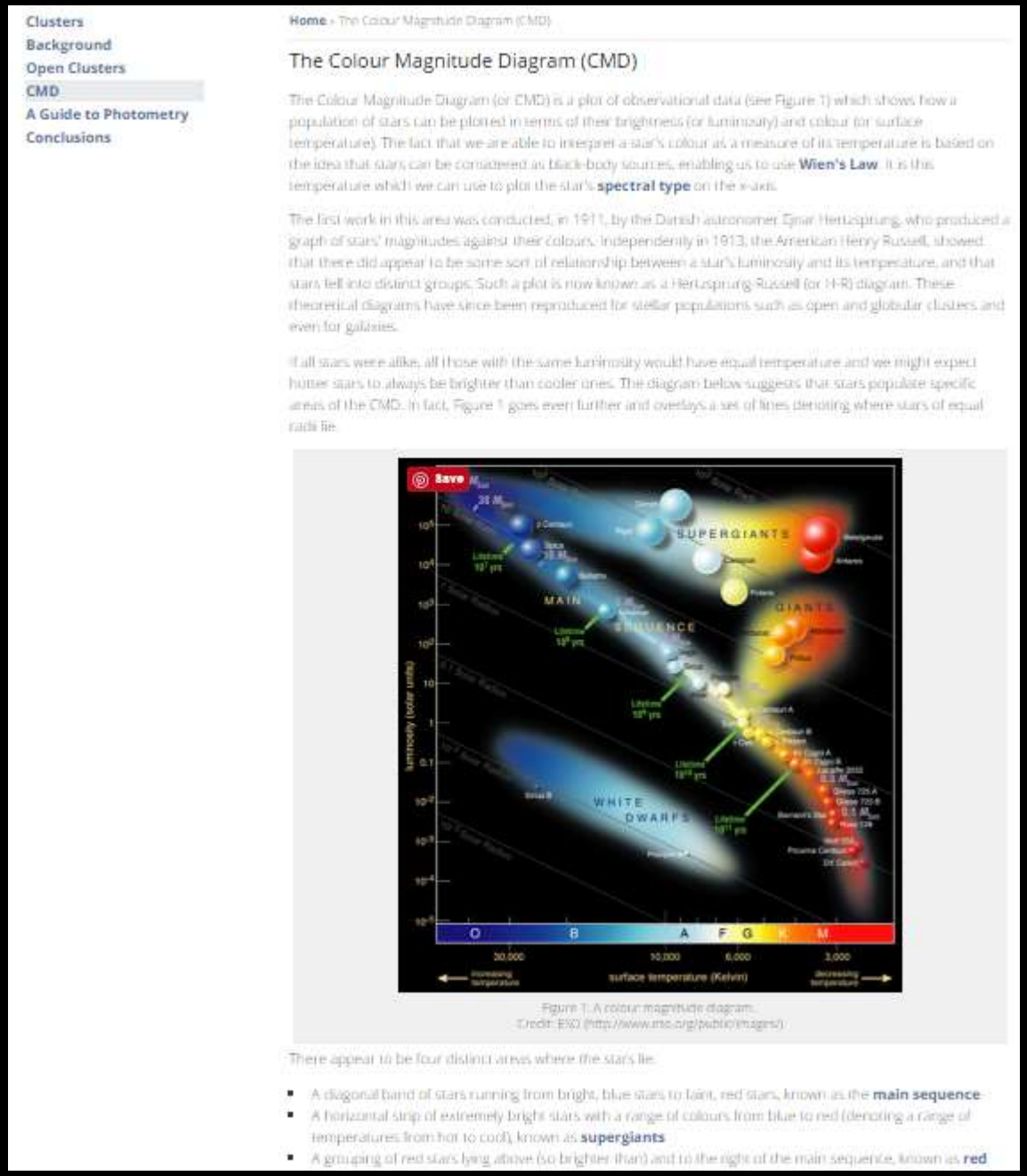
Not all stars emit light with a constant brightness and radiation output, many of them **change in brightness very suddenly** and often unexpectedly, over a variety of timescales. We call these objects **transients**.

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.**

http://resources.faulkes-telescope.com/course/view.php?id=144

http://resources.faulkes-telescope.com/course/category.php?id=48




Inquiry-based (IBSE) ‘teacher-free’ activity for students to learn about open clusters and HR diagrams as well as photometry using Makali’I (and all the nasty maths)

Students can choose any one of 28 existing datasets or explore the archives or take their own observations with one of our telescopes

https://www.schoolsobservatory.org/discover/projects/clusters/main

# NEW in 2020 !

Datasets on Type Ia Supernovae

Background material

How to do photometry using **JS9 (online tool)** inc. screencasts

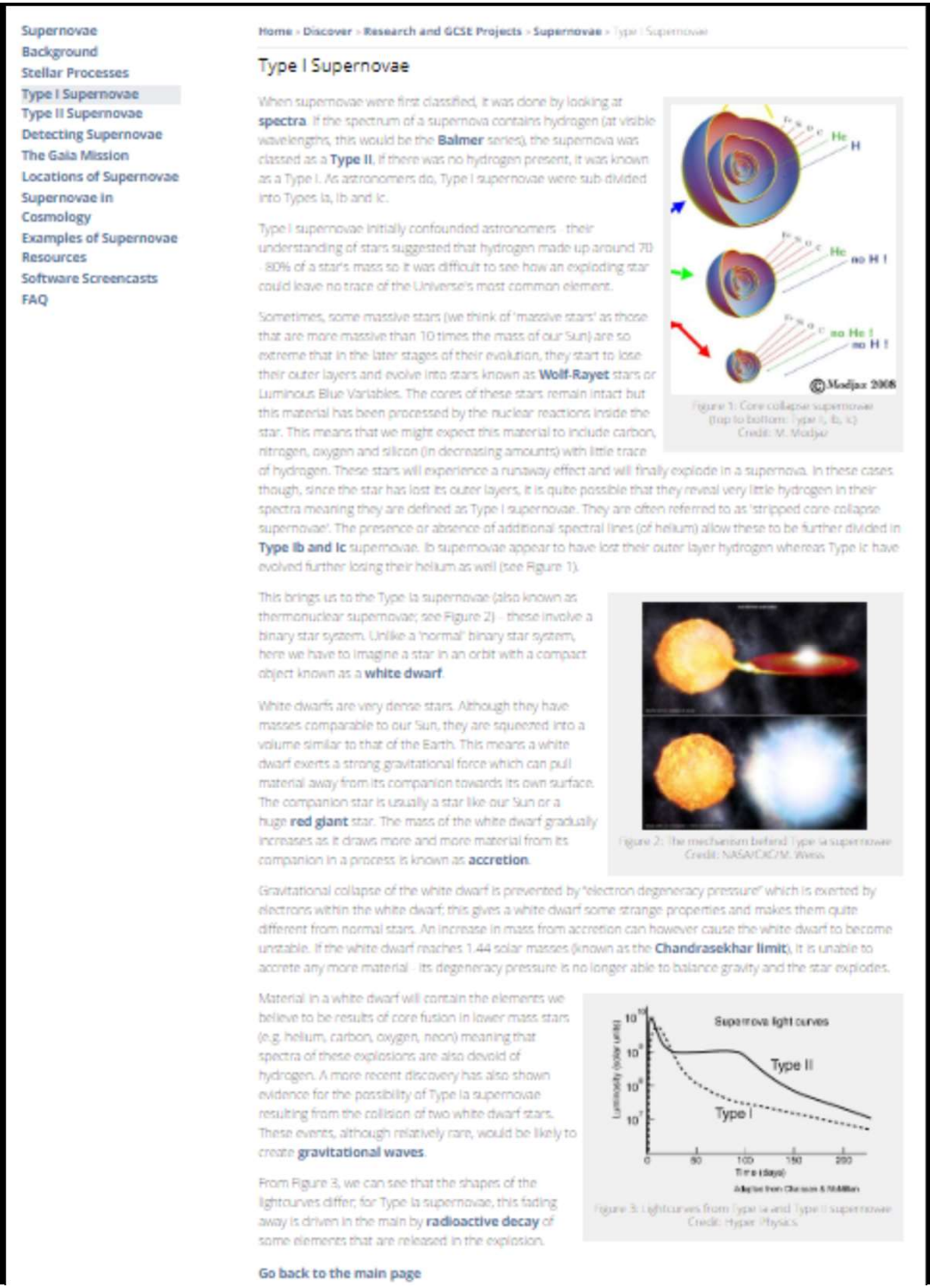
Put your values into an Excel sheet

Calculate the peak brightness and use that to calculate the distance to the host galaxy

Plot your data on the Hubble plot and calculate the age of the Universe !

Use Gaia/Rubin (LSST) to add new objects

https://www.schoolsobservatory.org/discover/projects/supernovae/



Supernovae
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Stellar Processes
Type I Supernovae
Type II Supernovae
Detecting Supernovae
The Gaia Mission
Locations of Supernovae
Supernovae in Cosmology
Examples of Supernovae
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## Type I Supernovae

When supernovae were first classified, it was done by looking at **spectra**. If the spectrum of a supernova contains hydrogen (at visible wavelengths, this would be the **Balmer** series), the supernova was classed as a **Type II**. If there was no hydrogen present, it was known as a Type I. As astronomers do, Type I supernovae were sub divided into Types Ia, Ib and Ic.

Type I supernovae initially confounded astronomers - their understanding of stars suggested that hydrogen made up around 70 - 80% of a star's mass so it was difficult to see how an exploding star could leave no trace of the Universe's most common element.

Sometimes, some massive stars (we think of 'massive stars' as those that are more massive than 10 times the mass of our Sun) are so extreme that in the later stages of their evolution, they start to lose their outer layers and evolve into stars known as **Wolf-Rayet** stars or Luminous Blue Variables. The cores of these stars remain intact but this material has been processed by the nuclear reactions inside the star. This means that we might expect this material to include carbon, nitrogen, oxygen and silicon (in decreasing amounts) with little trace of hydrogen. These stars will experience a runaway effect and will finally explode in a supernova. In these cases though, since the star has lost its outer layers, it is quite possible that they reveal very little hydrogen in their spectra meaning they are defined as Type I supernovae. They are often referred to as 'stripped core collapse supernovae'. The presence or absence of additional spectral lines (of helium) allow these to be further divided in **Type Ib and Ic** supernovae. Ib supernovae appear to have lost their outer layer hydrogen whereas Type Ic have evolved further losing their helium as well (see Figure 1).



Figure 1: Core collapse supernovae (top to bottom: Type II, Ib, Ic)
Credit: M. Modjaz

This brings us to the Type Ia supernovae (also known as thermonuclear supernovae; see Figure 2) - these involve a binary star system. Unlike a 'normal' binary star system, here we have to imagine a star in an orbit with a compact object known as a **white dwarf**.



Figure 2: The mechanism behind Type Ia supernovae
Credit: NASA/CXC/M. Weiss

White dwarfs are very dense stars. Although they have masses comparable to our Sun, they are squeezed into a volume similar to that of the Earth. This means a white dwarf exerts a strong gravitational force which can pull material away from its companion towards its own surface. The companion star is usually a star like our Sun or a huge **red giant** star. The mass of the white dwarf gradually increases as it draws more and more material from its companion in a process is known as **accretion**.

Gravitational collapse of the white dwarf is prevented by "electron degeneracy pressure" which is exerted by electrons within the white dwarf; this gives a white dwarf some strange properties and makes them quite different from normal stars. An increase in mass from accretion can however cause the white dwarf to become unstable. If the white dwarf reaches 1.44 solar masses (known as the **Chandrasekhar limit**), it is unable to accrete any more material - its degeneracy pressure is no longer able to balance gravity and the star explodes.

Material in a white dwarf will contain the elements we believe to be results of core fusion in lower mass stars (e.g. helium, carbon, oxygen, neon) meaning that spectra of these explosions are also devoid of hydrogen. A more recent discovery has also shown evidence for the possibility of Type Ia supernovae resulting from the collision of two white dwarf stars. These events, although relatively rare, would be likely to create **gravitational waves**.




Figure 3: Lightcurves from Type Ia and Type II supernovae
Credit: Hyper Physics

From Figure 3, we can see that the shapes of the lightcurves differ, for Type Ia supernovae, this fading away is driven in the main by **radioactive decay** of some elements that are released in the explosion.

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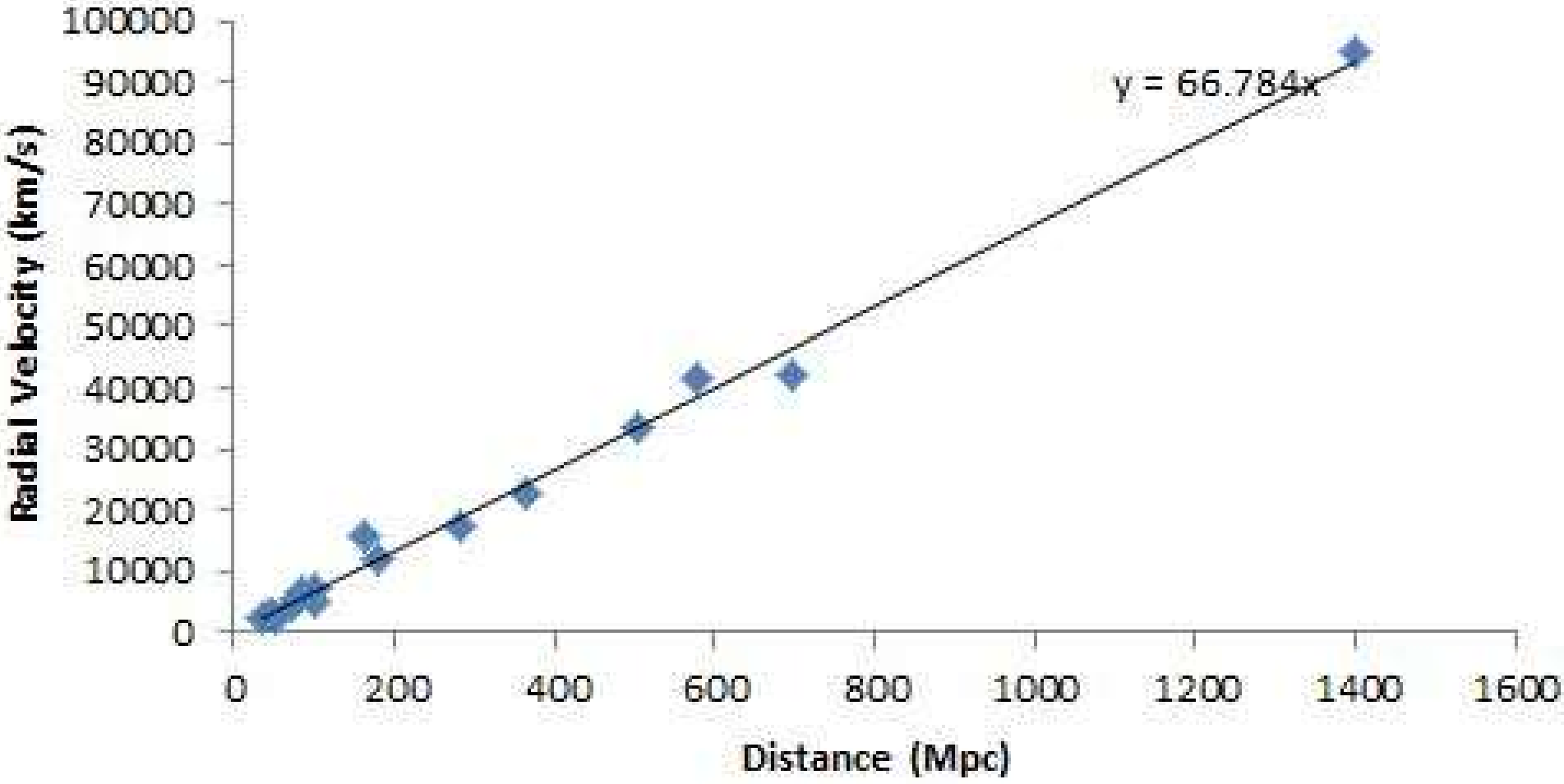
# Hubble Diagram



# Also Required

**Finding Suitable Targets**

Stellarium, Python

**Data Analysis**

Salsa J, Makali'I, JS9, AstroImageJ (i.e. free photometry software)

Excel/Google Spreadsheets

# Transferable Skills

**Apart from astronomy, we want students and/or citizens to …**

Gain an insight into the scientific process (collect, analyse and report) and the collaborative nature of science

Experience e.g. periodicity, trend lines, logarithms, errrorbars, independent research (not always working towards ‘the answer’)

Develop their own projects and make their own suggestions for extensions or diversions

# Problems and Hurdles

Projects require background information – balancing act between ‘enough’ and ‘too much’

Installing software – different platforms, operating systems

Not working towards ‘the answer is 12’

We can provide sample datasets but when students are let loose on real data, things become more difficult

Timescales involved e.g. data from a 2018 SNe was only recently published

# Eastbury Community Sch
# a lesson in how to plot a
# the Royal Astronomical S

Eastbury Community School students in action.

Megan Greet (Head of physics), Jamie Paton (teac
School were delighted to be invited to the Royal A
that teenagers really can carry out genuine scienti
Research in Schools, led by Becky Parker, Eastbury were selected as the pilot school to analyse data from the Gaia project. This is a wonderful opportunity to enhance the enrichment work being

**Eastbury Physics**
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Us giving presentation @RoyalAstroSoc on supernovae found in data from #GaiaMission provided by @ResearchInSch

# Schools in research publications

*Astronomy & Astrophysics* manuscript no. paper
October 1, 2020


## Gaia18aen: First symbiotic star discovered by *Gaia*

J. Merc[1,2⋆], J. Mikołajewska[3], M. Gromadzki[4], C. Gałan[3], K. Iłkiewicz[3,5], J. Skowron[4], Ł. Wyrzykowski[4], S. T. Hodgkin[6], K. A. Rybicki[4], P. Zieliński[4], K. Kruszyńska[4], V. Godunova[7], A. Simon[8], V. Reshetnyk[8], F. Lewis[9,10], U. Kolb[11], M. Morrell[11], A. J. Norton[11], S. Awiphan[12], S. Poshyachinda[12], D. E. Reichart[13], M. Greet[14], and J. Kolgjini[14]

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[8] Faculty of Physics, Taras Shevchenko National University of Kyiv, 4 Glushkova Ave., Kyiv, 03022, Ukraine
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[10] Astrophysics Research Institute, Liverpool John Moores University, 146 Brownlow Hill, Liverpool L3 5RF, UK
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[12] National Astronomical Research Institute of Thailand, 260, Moo 4, T. Donkaew, A. Mae Rim, Chiang Mai, 50180, Thailand
[13] Department of Physics and Astronomy, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA
[14] Eastbury Community School, Hulse Avenue, Barking IG11 9UW, UK

# Where next

As always, driven by funding … !

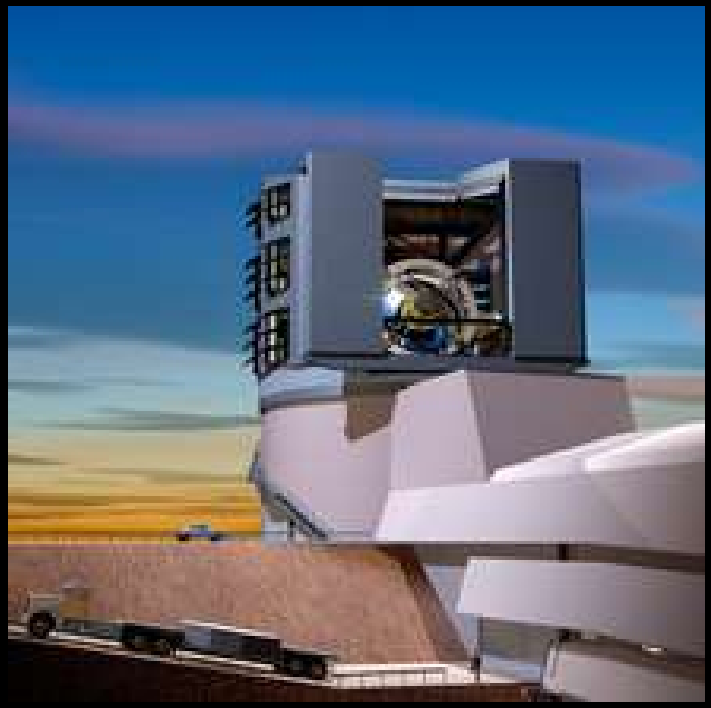
Hoping to develop more IBSE-type resources around variable stars, compact objects, spectroscopy

So much more we could do with Gaia DR too

# Rubin Observatory (LSST)

8.4 metre survey telescope in Cerro Pachon, Chile

10 year survey starting in 2022 producing ~1 petabyte of data per year (1 PB = 1000 TB = 1 million GB)



*"[I feel] like you are doing something in physics instead of experiments where everybody already knows the answer."*

NSO Student

"I hear and I forget,
I see and I remember,
I do and I understand."

Confucius

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In Spain: https://www.iac.es/peter/registra-tu-centro

LIVERPOOL JOHN MOORES UNIVERSITY

You can register for the FT Project (it's free, honest !)

UK and Ireland

Spain

https://www.iac.es/peter/registra-tu-centro/

Everywhere else

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