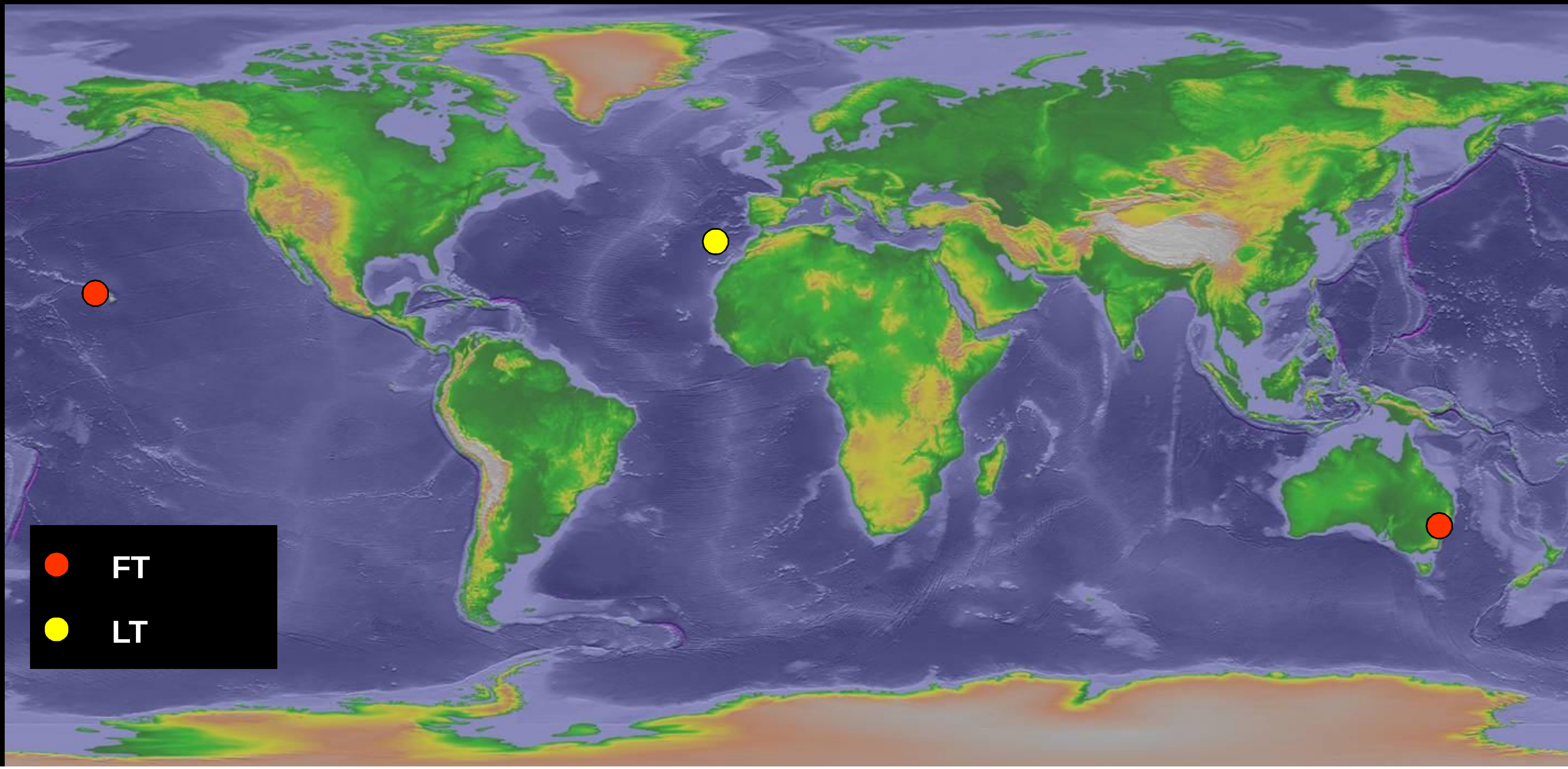
Linking Education and Research Using Robotic Telescopes

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



Spotting a Supernova Worksheet

esa

gaia

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

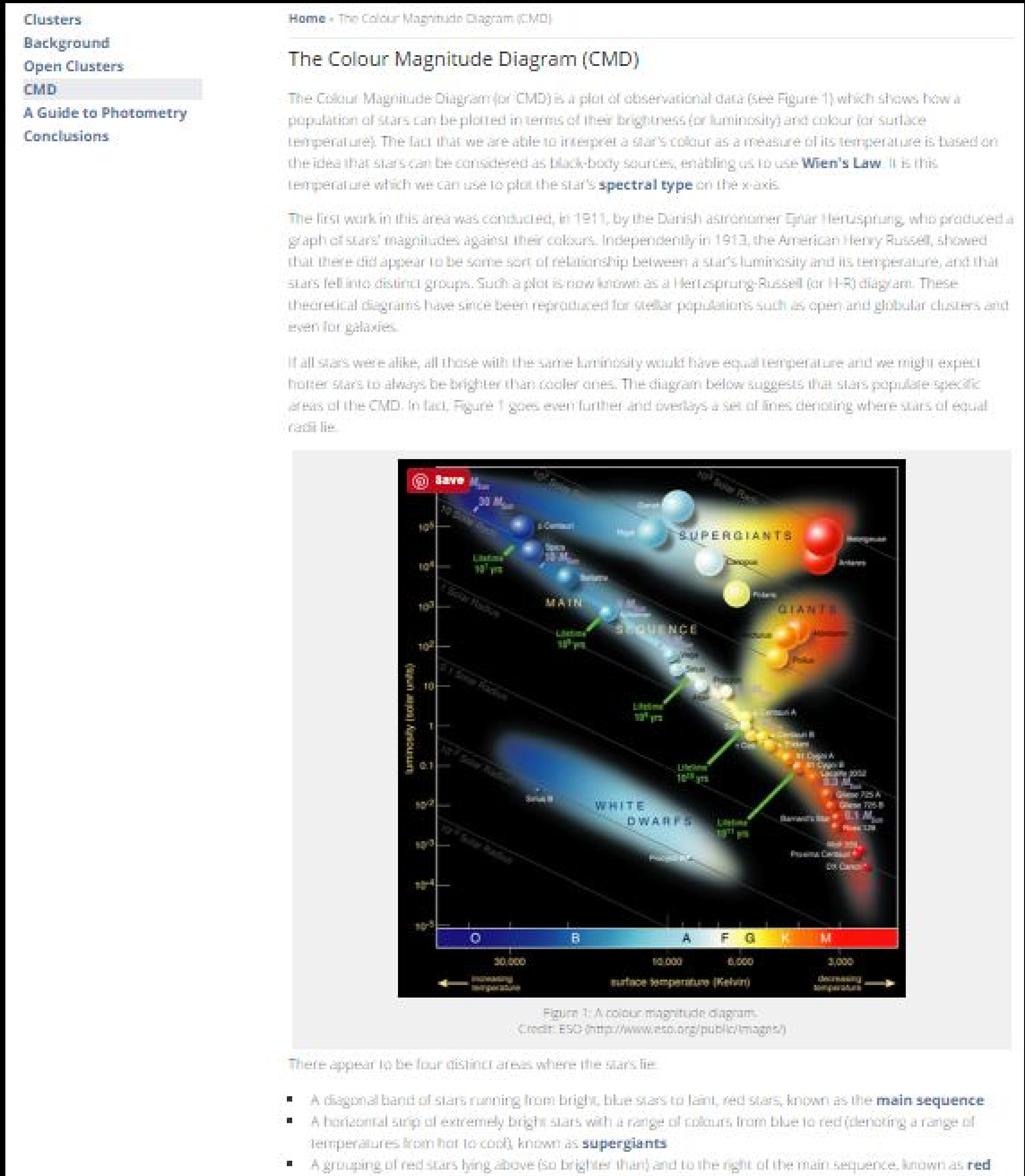
Schools in research publications

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]

1 Astronomical Institute, Faculty of Mathematics and Physics, Charles University, V Holešovičkách 2, 180 00 Prague, Czechia
2 Institute of Physics, Faculty of Science, P. J. Šafárik University, Park Angelinum 9, 040 01 Košice, Slovakia
3 Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, Bartycka 18, 00–716 Warsaw, Poland
4 Astronomical Observatory, University of Warsaw, Al. Ujazdowskie 4, 00-478 Warszaw, Poland
5 Department of Physics and Astronomy, Box 41051, Science Building, Texas Tech University, Lubbock, TX 79409-1051, USA
6 Institute of Astronomy, University of Cambridge, Madingley Road CB3 0HA, Cambridge, UK
7 ICAMER Observatory of NASU, 27 Acad. Zabolotnoho str., Kyiv, 03143, Ukraine
8 Faculty of Physics, Taras Shevchenko National University of Kyiv, 4 Glushkova Ave., Kyiv, 03022, Ukraine
9 Faulkes Telescope Project, School of Physics, and Astronomy, Cardiff University, The Parade, Cardiff CF24 3AA, UK
10 Astrophysics Research Institute, Liverpool John Moores University, 146 Brownlow Hill, Liverpool L3 5RF, UK
11 School of Physical Sciences, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK
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



Clusters
Background
Open Clusters
CMD
A Guide to Photometry
Conclusions

Home › The Colour Magnitude Diagram (CMD)

The Colour Magnitude Diagram (CMD)

The Colour Magnitude Diagram (or CMD) is a plot of observational data (see Figure 1) which shows how a population of stars can be plotted in terms of their brightness (or luminosity) and colour (or surface temperature). The fact that we are able to interpret a star's colour as a measure of its temperature is based on the idea that stars can be considered as black-body sources, enabling us to use **Wien's Law**. It is this temperature which we can use to plot the star's **spectral type** on the x-axis.

The first work in this area was conducted, in 1911, by the Danish astronomer Ejnar Hertzsprung, who produced a graph of stars' magnitudes against their colours. Independently in 1913, the American Henry Russell, showed that there did appear to be some sort of relationship between a star's luminosity and its temperature, and that stars fell into distinct groups. Such a plot is now known as a Hertzsprung-Russell (or H-R) diagram. These theoretical diagrams have since been reproduced for stellar populations such as open and globular clusters and even for galaxies.

If all stars were alike, all those with the same luminosity would have equal temperature and we might expect hotter stars to always be brighter than cooler ones. The diagram below suggests that stars populate specific areas of the CMD. In fact, Figure 1 goes even further and overlays a set of lines denoting where stars of equal radii lie.

Figure 1: A colour magnitude diagram.
Credit: ESO (http://www.eso.org/public/images/)

There appear to be four distinct areas where the stars lie.

- A diagonal band of stars running from bright, blue stars to faint, red stars, known as the **main sequence**
- A horizontal strip of extremely bright stars with a range of colours from blue to red (denoting a range of temperatures from hot to cool), known as **supergiants**
- A grouping of red stars lying above (so brighter than) and to the right of the main sequence, known as **red**

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

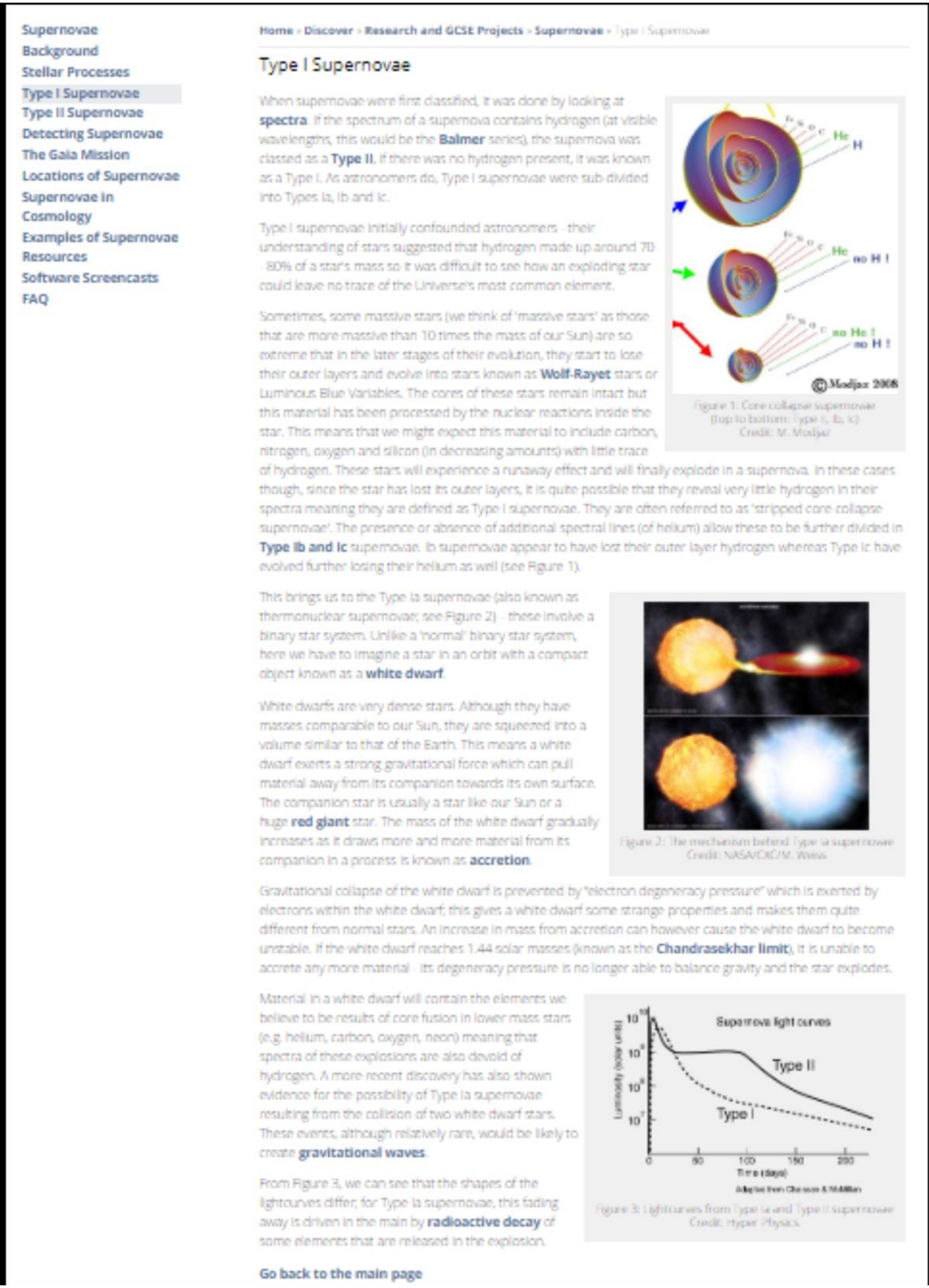
Put your values into an Excel sheet

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
Background
Stellar Processes
Type I Supernovae
Type II Supernovae
Detecting Supernovae
The Gaia Mission
Locations of Supernovae
Supernovae in Cosmology
Examples of Supernovae
Resources
Software Screencasts
FAQ

Home › Discover › Research and GCSE Projects › Supernovae › Type I Supernovae

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 I, 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**.

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**.

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

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.

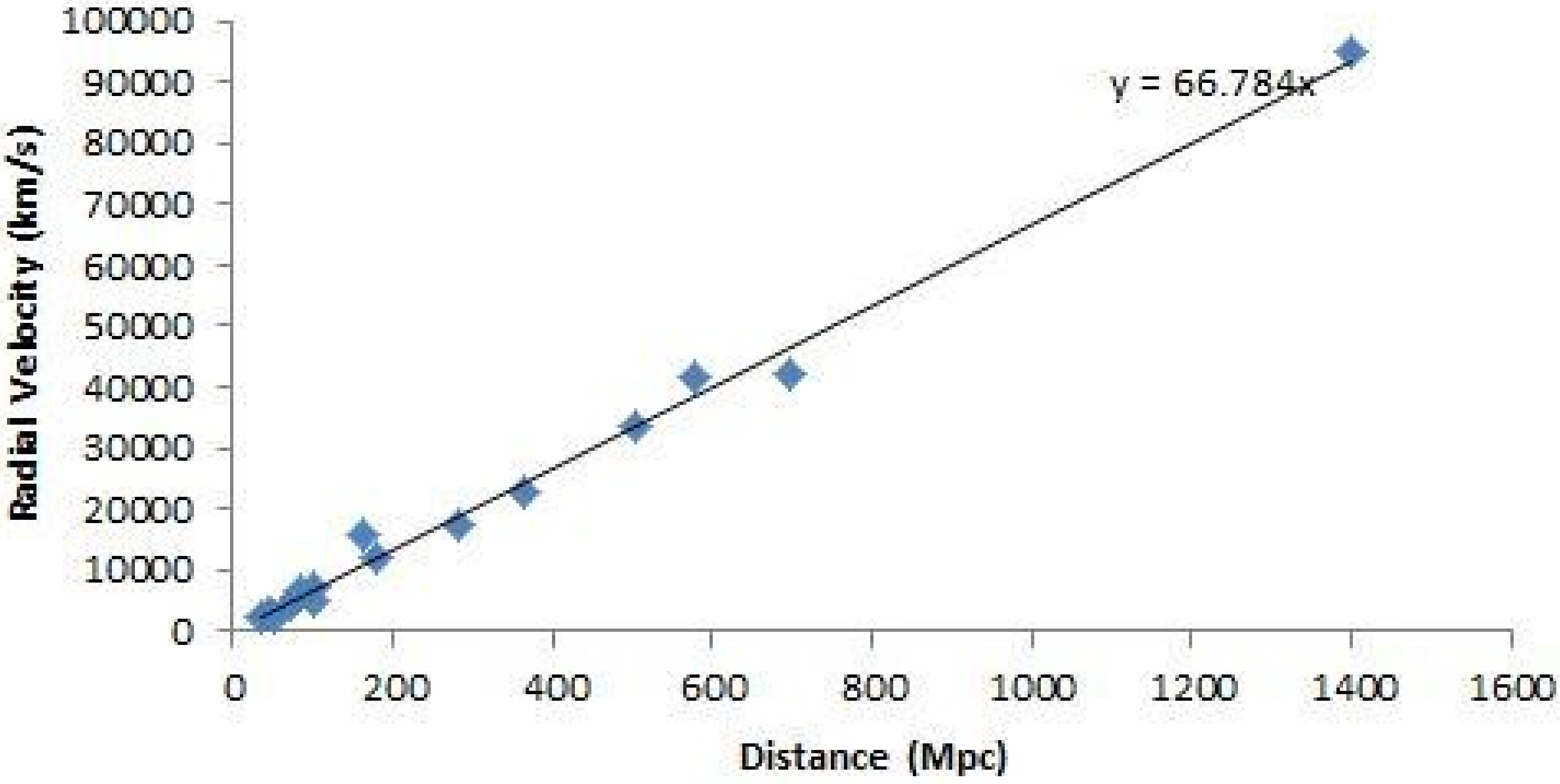
Material in a white dwarf will contain the elements we believe to be results of core fusion in lower mass stars (e.g. helium, carbon, oxygen, neon) meaning that spectra of these explosions are also devoid of hydrogen. A more recent discovery has also shown evidence for the possibility of Type Ia supernovae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

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.

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

Go back to the main page

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

Where next

As always, driven by funding ... !

But FT will be able to promote and support these types of projects more easily in 2021

Use of BH-TOM will really help us here

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

FAULKES TELESCOPE

Please check out these resources or
e-mail me your ideas

fraser.lewis@
faulkes-telescope.com

http://faulkes-telescope.com

http://resources.faulkes-telescope.com

http://education.down2earth.eu

http://www.schoolsobservatory.org.uk/

@faulkestel

@schoolsobs