Explosions in the Sky: Supernovae Type Ia
Georgios Dimitriadis
Email: gd1g13@soton.ac.uk

Introduction
Supernovae Type Ia (SNe Ia) are massive thermonuclear explosions of an Earth-sized star called a white dwarf (WD). They occur as the WD gains material from a neighbouring companion star, until it cannot longer support itself against gravity, at which point it explodes. The SNe Ia explosions are always uniformly bright and of the same magnitude. This reliability allows astronomers to calculate accurate distances from the earth to the supernovae even when they occur in distant galaxies.

Combining this information with an independent distance measurement called redshift, we are able to investigate the composition of the Universe, since different cosmological models predict different behaviours of redshift vs. distance.

In 2011, S. Perlmutter, B. Schmidt and A. Riess were awarded the Nobel Prize in Physics, following work in this scientific area, proving the existence of Dark Energy, a previously unknown but significant (~70%) component of our Universe.

Before the explosion: The Progenitor Problem of Supernovae Type Ia
While SNe Ia are a widely used astronomical tool, little is known about the configuration of the double star system that leads to the explosion. This is known in the scientific community as the Progenitor Problem. The main question is about the nature of the companion star, that provides the extra material, gained by the exploding white dwarf.

Two main suggestions have been proposed:
- The Single Degenerate Scenario (SD), in which the companion is a common star, just like our Sun.
- The Double Degenerate Scenario (DD), in which the companion is another white dwarf.

Astronomers use various scientific tools to examine this longstanding astrophysical problem. From the theoretical perspective, we create mathematical models that describe different stages of the phenomenon. Meanwhile, large observational programs are dedicated to find dozens of new SNe Ia each day. After being discovered, we continuously observe them for a long period of time.

When all the available data are collected, we can compare the actual observations with different explosion models to investigate: What was there, before the explosion in the sky?

Late time observations of SNe Ia
My work focuses on the observational signatures of SNe Ia at the later times of the phenomenon, almost 1-3 years after the explosion itself. At this time, the dominant energy source is radioactive decay. Heavy and unstable elements, such as Nickel (56Ni) and Cobalt (56Co), produced at the explosion, break apart and release high energy that heats the expanding debris. This heated material, called ejecta, is what I actually observe with telescopes.

By studying the shape of the light curve – brightness plotted against time – or the colour of the light that reaches us, I am able to test predictions of various theoretical models and measure important quantities that these models suggest.

At the left-hand side, the late time light curve of SN2011fe is plotted, where the data come from various telescopes. I also show a collection of spectra (amount of light plotted against colour of light) from different epochs. While the spectra don’t seem to change, the light curve changes at around 600 days after the explosion.

My work shows that, for some of the SNe Ia, new elements or other mechanisms, such as interaction with material around the explosion, should be considered, in order to explain the behaviour of the light curve.