Rapidly evolving Supernovae

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THE DARK ENERGY SURVEY

Introduction

Astronomical surveys are observing programs designed to discover new sources on the sky, and dedicated supernova surveys are discovering vast amounts of new **supernovae (SNe)**. These surveys are designed to find **Type Ia SNe**: violent explosions that happen when a remnant of a small, old Sun-like star, called a white dwarf, reaches a critical mass. These explosions are standardisable and hence can be used to measure cosmic distances to stars and galaxies. While looking for Type Ia SNe, the surveys also discover large numbers of other types of SNe. Most are **Core-Collapse SNe (CCSNe)**, that occur when a massive star exhausts the fuel in its core leading to a core-collapse, triggering an explosion. As more massive stars die younger, CCSNe are only found in recently **Star Forming Galaxies**. However due to the vast number of found SNe, surveys also pick up rarer, more peculiar events, such as the **Rapidly Evolving Supernovae (RESNe)** characterized by fast changes in brightness, with only a few tens discovered to date.

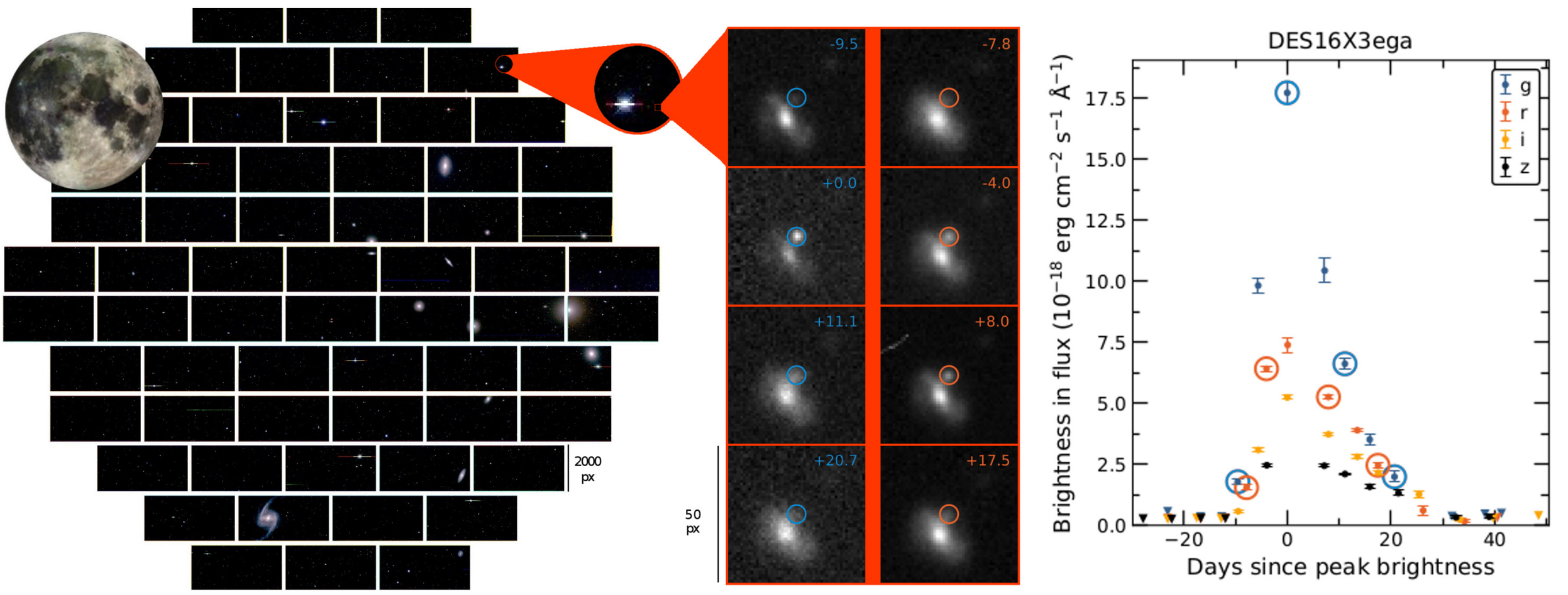

Figure 1: Full view of **Dark Energy Survey (DES)** with 62 4000 x 2000 pixel elements (left, Credit: Dark Energy Survey Collaboration), 50 x 50 pixel images of an example Rapidly Evolving Supernovae from my sample in two colors (middle) with corresponding 4-color light curve describing the evolution of brightness in time (right).

Rapidly Evolving Supernovae in DES

My work focuses on the RESNe and can be split into two parts:

1. **How to find RESNe in the DES data:**
   - Measure the duration of all discovered events in DES data
   - Visually go through the light curves of all fast events
     $\Rightarrow$ identify the RESNe!
   - 73 found so far and more data coming in!
2. **Analyze the data of RESNe:**
   - Rise to peak brightness in 10 days, disappear in 20-30 (Fig 1.)
     $\Rightarrow$ Type Ia SNe and CCSNe typically last few months!
   - From 15 times weaker to 15 times brighter than Ia SNe!
   - Hot – up to **30000 degrees** (Surface of Sun 6000 degrees)
   - Large – up to **100 times distance from Earth to Sun!**
   - Mostly expand/cool over time, but some appear to shrink!
   - Found in Star Forming Galaxies $\Rightarrow$ CCSNe?
   - **But why are they different?**

Future Work:

My future aim is to understand the nature of these peculiar transients and to find what is their relation to more common SNe.

What is the Dark Energy Survey?

Dark Energy Survey (DES) operates in the following manner:

- Studies cosmic distances with e.g. Type Ia SNe
- Has a field of view 15 times the size of full moon (Fig. 1)
- Images in 4 colors: g, r, i and z (Blue, Orange, Red, Infrared)
- Observes ten regions of sky called "fields" once a week
- Compares consecutive images to find differences in the fields
  $\Longrightarrow$ Discover variable sources!
- Tens of thousands found so far – but only fraction classified!

Conclusions

Rapidly Evolving Supernovae are a new and interesting type of SNe. Based on my sample of **73 discovered transients**, they evolve fast in brightness when compared with both Type Ia SNe and CCSNe. However as they are found only in **Star Forming Galaxies** they are likely related to CCSNe, but why they appear to be very different is still unclear.

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