SEARCH FOR LENSED SUPERNOVAE BY MASSIVE GALAXY CLUSTERS WITH THE 2.5m NORDIC OPTICAL TELESCOPE

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Abstract. We shortly present here the ongoing project by the Stockholm supernova group about the search of high-z supernovae with the ALFOSC camera at the Nordic Optical Telescope by using galaxy clusters as gravitational telescope.

1. INTRODUCTION

Supernovae are one of the most energetic phenomena in the Universe, making them a useful tool in cosmology and astrophysics. There are several varieties, classified by distinct spectral characteristics (Minkowski, 1941). Here we focus on type Ia. These are thought to be caused by thermonuclear explosions on a white dwarf accreting material from a companion. There is some debate whether the companion is a white dwarf or a giant phase star (the so called single degenerate scenario, Nomoto et al. 1984) or a two merging white dwarfs (the double degenerate scenario, Iben and Tutukov 1984). Nevertheless, Ia supernovae are believed to be good *standard candles* by using the correlation between the light curve shape and the peak brightness (Philips 1993). As such, they played a crucial role in demonstrating the accelerating expansion of the Universe, thought to be caused by the enigmatic *dark energy* (Riess et al. 1998, Perlmutter et al. 1999).

A wealth of supernova Ia discoveries, coupled with measurements of the cosmic background radiation and the baryonic acoustic oscillations form the foundation of modern precision cosmology (for a review on supernova cosmology see Goobar, A. & B. Leibundgut, 2011). Despite the success of the field, there are still open questions. Observation of high-redshift supernovae would serve to answer some of these, shedding light on the evolution of dark energy and stellar metallicity. Furthermore detecting supernovae Ia at $z \geq 1.2$ could help to solve the progenitor problem, where the predicted supernova rate is sensitive to the different scenarios.

Pushing observation of supernovae to high redshifts is difficult simply because they are faint. The Hubble Space Telescope provides the bulk of recent high-z discoveries. Utilizing massive galaxy clusters as magnifying lenses (Gunnarsson & Goobar 2003) enables ground telescopes to contribute to the search. In this way, supernovae could be magnified up to 5 magnitudes (Stanishev et al., 2009 and Goobar et al., 2009).

In 2009 the pilot survey was performed with ISAAC instrument on the Very Large Telescope (VLT) where a core-collapse supernova at z = 1.703 was discovered behind A1689 with magnification of $\Delta m_{lens} = 1.58 \pm 0.07 \text{ mag}$ (Amanullah R. et al. 2011).

2. NOTCLULESS - CLUSTER LENSED SUPERNOVA SURVEY

The Nordic Optical Telescope (NOT) is located at the Observatorio del Roque de los Muchachos on the island of La Palma in the Canaries, Spain. The telescope is a Ritchey-Chretien Cassegrain with a primary mirror of 2.56 m and focal ratio of f/11. The Andalucia Faint Object Spectrograph and Camera, ALFOSC, is a back illuminated CCD with 2048 per 2048 pixels. ALFOSC has a field of view of 6.4' per 6.4' in imaging mode, and can also be used for low/medium resolution spectroscopy and polarimetry.

In April 2012 we started our monthly *i*-band monitoring program on the galaxy clusters A1689, A2218 and A2219 with the ALFOSC. This is an example how a high-z sources can be put within the reach of a 2.5 m telescope.

With the POLOKA reduction software, we match and stack contemporaneous (same night) images. The search for supernovae candidates is done by the subtraction of different nights. The calibration of the data has been done by using the SDSS catalogue as a reference. To check the reliability of the method, an efficiency test was performed by adding simulated supernovae into the data. We estimate that a magnitude of i=24 (Vega) would be necessary to detect a supernova on A1689 at S/N=5 with a one-hour observation. We expect to find around 10 SNe (both Ia and core collapse) during ESO periods. The current work focuses on performing photometry on each monthly stack to obtain the candidate light curves.

Our group has also two near-infrared ESO VLT ongoing programs called Magnified view of high-z supernovae where we use HAWKI to find lensed supernovae behind two massive galaxy clusters (A1689 and A370) and Cherry Picked Supernovae: a Zoomed View of SN Ia and Dark energy to perform photometric and spectroscopic follow-up of the candidates (PI: Goobar).

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