# Mid-term report for BELSPO post-doctoral fellowship

**Rupak Roy**

## 1. Preamble

The evolution of massive stars having initial mass $\gtrsim 8 M_\odot$ (where $M_\odot$ is the mass of the Sun) constitutes one of the important and least understood topics of Astrophysics. The explosive events, like Supernovae (SNe), Gamma Ray Bursts (GRBs) or X-ray flashes (XRFs) are supposed to originate from the end stage of evolved massive stars. The proposed International Liquid Mirror Telescope (ILMT), which is expected to be in commission from the next year at Devasthal, India is supposed to discover many new transients along with SNe in high redshift galaxies during its entire period of operation.

## 2. Mid-term report

Being a PhD holder in the field of SNe, my proposed plan for the BELSPO post-doctoral fellowship was to characterize different kinds of Core-Collapse Supernovae (CCSNe) after collecting the data from existing telescopes through out the world as well as to develop 'pipeline programs' for photometry of the objects which will be observed with the ILMT. Hence this mid-term report is mainly divided in two sections: 'Work on CCSNe' and 'Work with ILMT'. Apart from these, I was also actively involved in a project on episodic jet-activity in Quasars (DDRQs), which is an extremely rare phenomenon and may be considered as a potential candidate in ILMT follow-up program.

### 2.1. Work on CCSNe

During the last six months I was mainly involved with two CCSNe projects, with myself as a leading author − one is on Type IIP SN 2012A and the other is on Type Ic SN 2012aa.

SN 2012A, occurred in the nearby galaxy NGC 3239, is a relatively low luminous IIP event. The SN was located in the star forming region of the host. So, it was necessary to get a good template of the field

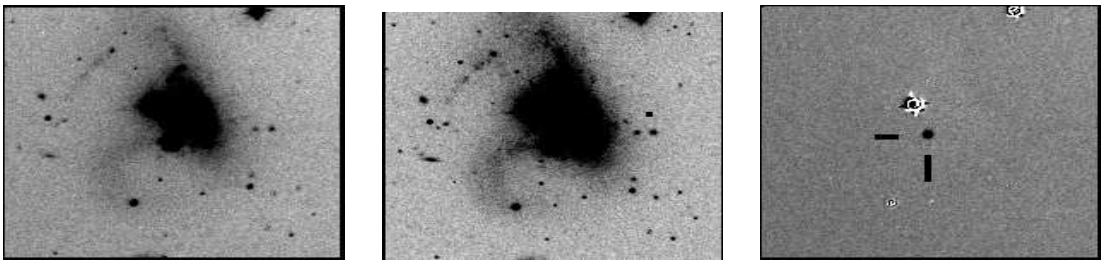

Fig. 1.— Measurement procedure of the true SN flux through an IRAF-based self-written pipeline. The leftmost panel shows *R*-band image observed on 2012 January 22 with a SN in it. The middle panel shows the template image taken on 2014 February 01, with no SN in it. The rightmost panel shows the subtracted image, where only the SN is present.

to perform the correct photometry of the transient. In February, 2014, We obtained the template in a good sky condition with the Sampurnanad Telescope (ST). The result of template subtraction is shown in Figure 1. The photometric and spectroscopic (both high and low resolution) analyses are in progress.

SN 2012aa is a Type Ic Super-luminous Supernova (SLSN), that occurred in a distant galaxy. We have photometric follow-up from ST and long term observations from CRTS. Several spectroscopic observations have been done from IGO, NTT, TNG, Gemini and Keck. The photometric and spectroscopic evolutions of the event (Figure 2) demonstrate the Interaction of the SN shock with the Circumsteller medium (CSM). Very recently the field has been recalibrated from ST. Further analysis of this event is also in progress.

We made a revision of one of my early work on SN 2007uy. The entire revision process has been done while staying at Liège during my post-doctoral period. The new work has been accepted for publication in MNRAS main journal (Roy et al., 2014).

### 2.2. Work with ILMT

I was involved in developing some standalone automated program for ILMT. The primary code is based on the new algorithm DANDIA, developed by Bramich (2008). I was initially assigned to calculate the 'seeing' along increasing time and declination. As, it was a new area of research to me, I first redid the entire calculation of DANDIA, and then tried to understand the existing code written in 'C' and also the associated softwares like 'Cfitsio'. I made so far 60−70% progress in this regard, and also expect to complete the rest part in very near future. I look-forward to hear for very exciting results from ILMT survey and would like to contribute more scientifically if situation permits.

### 2.3. Work on DDRQs

After completion of the doctoral program, I also got involved in the research on radio galaxies and quasars. This is another area of High-energy Astronomy which has emerged considerably during the last couple of years. Our first work (Nandi, Roy et al., 2014) on a DDRQ J0746+4526 has been accepted for publication in a reputed peer-reviewed journal. As one of the leading authors, I was involved in the interpretation of the observation of the optical-host. We found that the merger-driven scenario is one of the key triggering mechanism for recurrent activities in radio Quasars. This is the second quasar where recurrent activity has been found. Figure 3 shows the source as well as the spectra of the optical host.

## 3. Future Prospects

I am thankful to Prof. Jean Surdej and BELSPO for providing support to conduct my research activity during my stay in Belgium. The ongoing SNe projects are expected to get complete within the next 6 months. I also look forward to contribute in the ILMT project.

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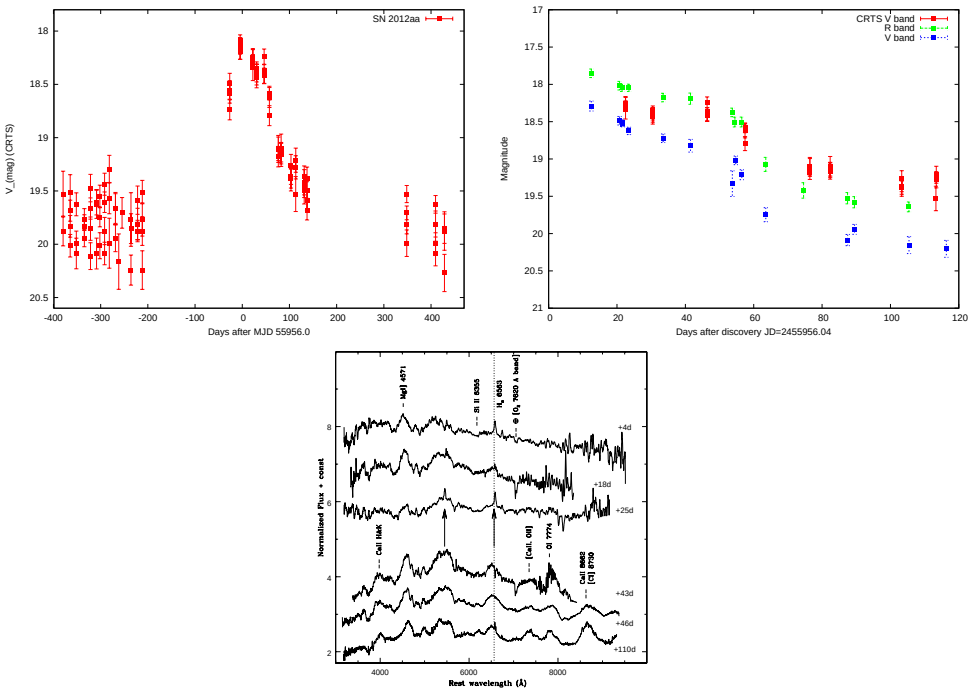


Fig. 2.— Photometric and Spectroscopic evolution of SN 2012aa.

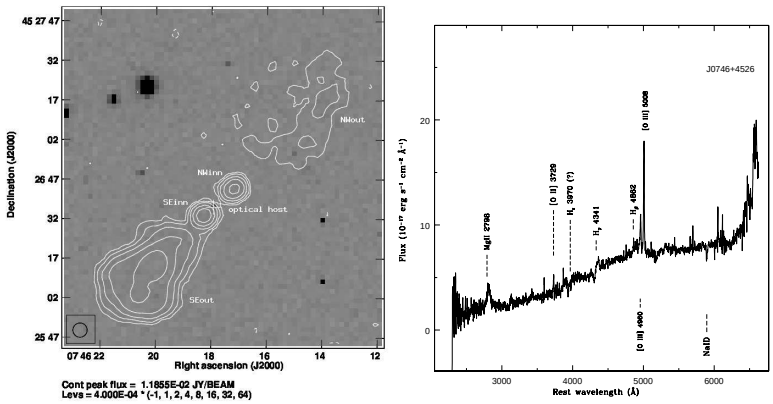


Fig. 3.— The radio Quasar J0746+4526. This is a red quasar with recurrent activity. Left panel is the FIRST image, superimposed on SDSS image. Right panel is the SDSS spectrum of the optical-host.