## Probing the progenitor scenario of stripped envelope

## supernovae using HCT

### Anjasha Gangopadhyay<sup>1</sup>, Kuntal Misra<sup>1</sup>, D.K.Sahu<sup>2</sup>, G.C.Anupama<sup>2</sup>, Raya Dastidar<sup>1</sup>et al.

Aryabhatta Research Institute of observational sciencES (ARIES), Nainital, India
Indian Institute of Astrophysics, Bangalore, India

अार्यभट्ट प्रेक्षण विज्ञान चोध संस्थान Aryabhatta Research Institute of Observation Science

Abstract: Stripped-envelope (SE-SNe) are the group of SNe that strip off their outer H-envelope due to high stellar winds or due to accretion. We analyse the isolated, unblended line profiles of Mg I] 4571 Å, [O I] 6300, 6364 Å and [Ca II] 7291, 7324 Å in the nebular spectra of a type IIb SN 2015as and three type Ib SNe 2015ap, PS15bgt and MOT taken with HFOSC, HCT to discern asymmetry. [O I] line profile shows either single, double or multi-peaked profiles depending upon geometrical ejecta configuration. Mg I] evolution shows an asymmetric structure similar to [O I] indicating similar origin within the SN ejecta. Less asymmetric [Ca II] lines mostly indicates the uniformly distributed pre-existing material. Estimation of [O I] mass indicates that the most likely progenitor scenario for SE-SNe are binary systems while massive Wolf-Rayet star stripping H envelope is favourable for SNe Ib.

#### **Motivation :**

Very few detections of direct progenitor from Hubble Space Telescope (HST)

#### **Asymmetric line profiles :**



- images.
- Only one Ib iPTF13bvn and 3 II'bs have known direct detections of progenitors.
- Indirect evidences are [O I] mass and [Ca II]/[O I] ratio which relates progenitor masses through hydrodynamical simulations.
- Prime reason for choosing [O I] profile ---
  - (a) isolated, unblended
  - (b) sensitivity of spectrographs maximum
  - Also, Serves as an important tool to discern asymmetry
  - An idea about type of explosion and dust formation

#### The Sample :

- One type IIb SN 2015as (Gangopadhyay et al. 2018, MNRAS)
- Three type Ibs
- SN 2015ap (Gangopadhyay et al. 2020, MNRAS)
- MASTER OT J120451.50+265946.6 (Singh et al. 2019, MNRAS)
- PS15bgt (Singh et al. 2020, ApJ, under revision)

#### **Oxygen profile features in type Ib SNe:**



#### Velocity (km/sec)

Fig 2 : Panel A, B and C shows highly asymmetric ejecta configuration of a type IIb SN 2015as. Panel A and B shows that [Mg I] and [O I] have similar distribution in SN ejecta. Systematic blueshifts observed in line evolution.

#### **Geometrical explanation** :

Oxygen torous or blob moving perpendicular to the line of sight. Multi-peaked profiles indicate blob moving towards and away from the observer.

#### **O** mass and **Progenitor** mass :

Fig 1 : The three panels of figure shows three kind of asymmetric profiles existing in SE-SNe. First two panels show asymmetric structures with a systematic blueshift while third panel shows multi-peaked oxygen profiles indicating blobs of oxygen moving at different directions.

#### **Asymmetries associated with line profiles :**

• Taubenberger et al. (2009) explored diversity among type IIb/Ib/Ic SNe.

• While Gaussian profiles indicate spherical explosions, asymmetric explosions are mostly produced by dust or residual opacity in the ejecta.

- Mg profile as shown in Fig 2 indicates that Mg and O originates from same region of SN ejecta because of similar profiles.
- Ca profile as seen in third panel of Fig 2 has no similarity with Mg and

# $M_O = 10^8 \times D^2 \times F([O I]) \times exp^{(2.28/T_4)},$

For type IIb SN 2015as : Oxygen mass  $\sim 0.44~M_{\odot}$ , For type Ib SN MASTER OT : Oxygen mass  $\sim 0.90~M_{\odot}$ , For type Ib SN 2015ap : Oxygen mass  $\sim 0.90~M_{\odot}$ , For type Ib SN PS15bgt : Oxygen mass  $\sim 0.85~M_{\odot}$ ,

Hydrodynamical simulations correlated progenitor mass with O mass . Above results indicate towards more massive progenitors of type Ib than type IIb SNe. Also, it implies that binary scenario is favourable for type IIb SNe.



The pseudo-equivalent width values of Hα estimated at early epochs (-2 to 2 days post V-maximum) indicates high value for type IIb SN 2015as while the value differs widely for two type Ib's.

This indicates that they are linked by continuum of Hydrogen layer.

#### **Conclusions** :

Diversity in O profile indicating asymmetric explosions with dust signatures. Type Ib progenitors are massive than IIb. Binarity is the favourable scenario. Type IIb and Ib



