Contribution ID: **12** Type: **Short Talk**

How to make a supernova associated with a Gamma-Ray Burst in the collapsar model ?

Wednesday, June 15, 2016 2:10 PM (10 minutes)

Gamma Ray Bursts (GRBs) are among the most energetic events in the universe. GRBs are divided by the duration time into long GRBs and short GRBs. A popular model of the central engine of long GRBs involves a hyper accreting black hole (BH), created by a core collapse of a massive star (the collapsar model) [1].
Indeed, supernovae (SNe) have been observed to be associated with some GRBs since 1998. For example, SN1998bw was connected to GRB980425, and this SN was a very energetic core collapse SN [2].
In the collapsar model, it has been suggested that there could be strong outflow from the hyper accreting disk around the BH, with a kinetic energy of about 10^52 erg [3, 4]. This wind could induce an energetic SN associated with a GRB.
However, what condition is needed for the wind to produce a core collapse SN has not been clarified. Also, a possible relation between features of GRBs and those of associated SNe with in this scenario is not clarified either.
So, we explore what kind of a progenitor star could explode a GRB and an SN, and investigate mutual relations between the GRB and SN expected within a context of the collapsar model. We develop a simple model to describe a system consisting of a BH, disk and infaling surrounding envelope as a result of a core collapse of a massive star, adopting a range of progenitor structures (e.g., angular momentum). We evolve the system by calculating the mass and angular momentum transfer between these three components, largely following prescriptions given by Kumar et al. 2008 [5]. Furthermore, we include the effect of the ram pressure of the infalling materials to evaluate a capability of the wind to induce an SN explosion, and estimate nucleosynthesis properties, following methods by Maeda and Tominaga 2009 [6].
We found that some relations are expected between properties of GRBs and those of SNe in the collapsar context. Some models result in the wind kinetic energy exceeding 10^51 erg, associated with a GRB jet kinetic energy of 10^53 erg. However, we also found that it is generally difficult for the wind to explode an SN because of the high ram pressure of the infalling materials. Using these results, we further discuss what is required for the properties of the wind and the central engine to simultaneously produce a GRB and an SN.

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Session Classification: Students1