A collapsar model with disk wind: implications for supernovae associated with a gamma-ray burst

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We construct a simple but self-consistent collapsar model for gamma-ray bursts (GRBs) and SNe associated with GRBs (GRB-SNe)[1]. Our model includes a black hole, an accretion disk, and the envelope surrounding the central system (Figure.1). The evolutions of the different components are connected by the transfer of the mass and angular momentum[2]. To address properties of the jet and the wind-driven SNe, we consider competition of the ram pressure from the infalling envelope and those from the jet and wind[3]. The expected properties of the GRB jet and the wind-driven SN are investigated as a function of the progenitor mass and angular momentum. We find two conditions which should be satisfied if the wind-driven explosion is to explain the properties of the observed GRB-SNe. (1) The wind should be collimated at its base, and (2) it should not prevent further accretion even after the launch of the SN explosion. Under these conditions, some relations seen in the properties of the GRB-SNe could be reproduced by a sequence of different angular momentum in the progenitors. Only the model with the largest angular momentum could explain the observed (energetic) GRB-SNe, and we expect that the collapsar model can result in a wide variety of observational counterparts mainly depending on the angular momentum of the progenitor star(Figure.2).

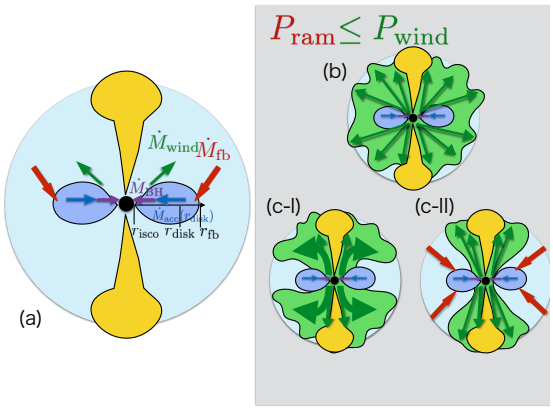

Figure 1: Cartoon for the calculation.

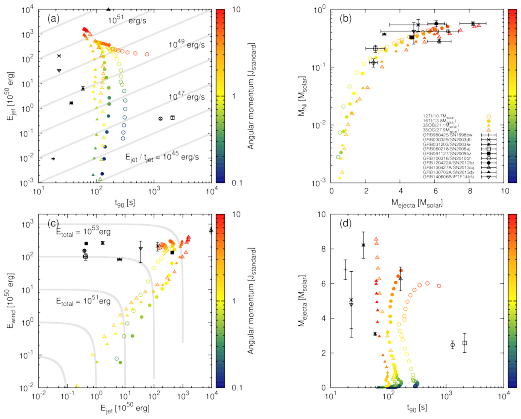

Figure 2: Expected properties of the GRB-SNe in our models (color points), as compared to the observed ones (black dots).

References

[1] Hayakawa, T. and Maeda, K. 2018, **ApJ**, 854, 43

[2] Kumar, P., Narayan, R., & Johnson, J. L. 2008, **MNRAS**, 388, 1729

[3] Maeda, K., & Tominaga, N. 2009, **MNRAS**, 394, 1317