Magnetars or Central Explosions in Superluminous Supernovae?

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The number of Superluminous Supernovae (SLSNe) discovered is growing. We show that the models explaining those events with the minimum energy budget involve multiple ejections of mass in presupernova stars. Mass loss and buildup of envelopes around massive stars are generic features of stellar evolution. Normally, those envelopes are rather diluted, and they do not change significantly the light produced in the majority of supernovae.

In some cases, large amount of mass are expelled just a few years before the final explosion. Then, the "clouds" around supernovae may be quite dense. The shock waves produced in collisions of supernova ejecta and those dense shells may provide the required power of light to make the supernova much more luminous than a "naked" supernova without pre-ejected surrounding material.

This class of the models is referred to as "interacting" supernovae. We show in [1] that the interacting scenario is able to explain both fast and slowly fading SLSNe, so the large range of these intriguingly luminous objects can in reality be almost ordinary supernovae placed into extraordinary surroundings.

Many SLSNe-I have photospheric velocity of order 10^4 km/s which is hard to explain in interacting models with modest energy of explosion. That is why to explain those events a "magnetar" central engine is invoked. However, the magnetars postulated in this scenario are not yet observed, and the physics of transformation of their rotational energy into photon luminosity requires a detailed investigation.

Our new study shows that a strong explosion (on the observed hypernova scale) within a dense envelope produced by previous weaker explosions explains naturally both high luminosity and high photospheric velocity of SLSNe.

References

[1] E. Sorokina, S. Blinnikov, K. Nomoto, R. Quimby, & A. Tolstov *ApJ* 829, 17 (2016)

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