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X-ray emission from Young Supernovae in Starbursts

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Abstract. We have collected from the literature X-ray fluxes of Young Supernovae, measured with various instruments. After converting the data to one energy range, we have compared the X-ray light curves of these objects. The X-ray luminosities of early Supernovae show coherent trends with Supernova type and provide significant, though short-lived contributions to the X-ray luminosity of Starbursts.

Young Supernovae are strong soft X-ray emitters. Produced by a massive progenitor, they have luminosities that span a large energy range, from about 10^{41} erg s^{-1} down to 10^{34} erg s^{-1}. Imaging X-ray satellite observatories have been successful in detecting a number of recent extragalactic Supernovae.

We have collected from the literature and from the Web page of S. Immler† the pertinent X-ray measurements of these Young Supernovae and have reduced their lightcurve fluxes to the 0.1–2.4 keV spectral window, with appropriate assumptions for spectral shapes (see next paragraph). After conversion to luminosities, the resulting data points are presented homogeneously in one diagram (Figure 1).

In Figure 1 we have plotted these X-ray luminosities versus Supernova age for almost all known X-ray detected Young Supernovae. Objects for which Supernova type or date since outburst are uncertain have been excluded from this sample. Fluxes have been converted to the chosen energy range by using the spectral parameters provided in the original papers (see Immler†; Sutaria *et al.* 2003 (SN2002ap)). Noticeable is the case of SN 1993J for which it is believed that two components are present of which the hard component is dominant at early times (Immler, private communication). For this case we have assumed the hard spectrum up to day 100 and a purely soft component after that.

If we compare the X-ray luminosities belonging to various kinds of Supernova events in Figure 1 and the distribution of Supernova types with mass and metallicity in Figure 2 of Heger *et al.* (2003), we can identify relatively narrow luminosity ranges in which certain Supernova types occur. We notice that the two SN IIp types have very similar luminosities of the order of 10^{38} erg s^{-1} at peak. These Supernovae are supposed to have progenitors of masses between 10 and 25–40 $M_\odot$ and a wide range of metallicities. In a similarly well defined energy band one can find the II L types with 10^{39} erg s^{-1} at peak. In the same area one finds the only example of a IIb type. Both IIL and IIb types are thought to be produced at higher metallicities, in a very narrow range of masses between approximately 20–40 $M_\odot$. The Supernovae IIn occupy a well defined band at the top of the luminosity range above approximately $10^{39.5}$ erg s^{-1} at peak. A progenitor is not explicitly identified by Heger *et al.* for these Supernovae. There are indications in the

† http://www.astro.umass.edu/astpage/xray/heag.html

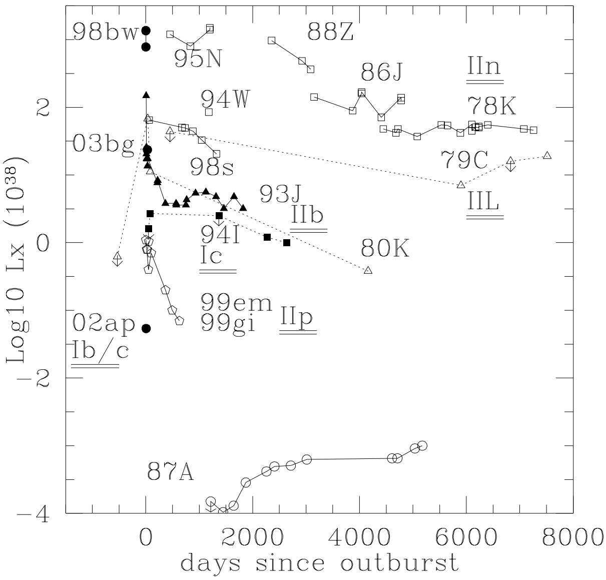

Figure 1. X-ray light curves in the energy range 0.1–2.4 keV versus Supernova age for all the known X-ray Supernovae for which reliable data are available. Different Supernova types are indicated with different colours and symbols. The 1998bw Supernova is believed to be associated with a γ-ray burst.

literature that their high luminosity depends on special conditions in the circumstellar medium, such as high density or clumpiness of the medium.

The X-ray luminosities of Type Ib/c Supernovae are actually varying widely over an energy range from a little over 10^{37} erg s^{-1} for SN 2002ap and around 10^{41} erg s^{-1} for SN 1998bw. On the other hand, three out of four of these Supernovae are fairly recent and only one X-ray point could be determined for each case. These Supernovae are thought to be formed from high mass progenitors ($>40 M_{\odot}$) and for high metallicity, conditions that are required for the star to lose effectively the outer H envelope. In low metallicity environments, binary evolution may be required in order to lose the H envelope. If to this we add that SN 1998bw has been associated with a γ-ray burst it becomes evident that there maybe more than one kind of progenitor associated to these Supernova events, which would fit with them showing a wide range of X-ray luminosities.

The Supernova 1987A stands out for the very low X-ray luminosity. On the other hand this is a peculiar Supernova in many respects, possibly because the progenitor was in a region of low metallicity. Also the X-ray light curve is still increasing and therefore a peak X-ray luminosity is not easily established.

Most of the light curves lie above 10^{38} erg s^{-1} for the first ca 50 years. Thus, Young Supernovae provide significant, though short-lived contributions to the X-ray luminosity of Starbursts.

References

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