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Relative frequencies of supernovae versus properties of spiral hosts

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Abstract. In this work, we present an analysis of SNe number ratios in spiral galaxies with different morphological subtypes, luminosities, sSFR, and metallicities, to provide important information about the physical properties of the progenitor populations.

Keywords. supernovae: general – galaxies: spiral

We investigate the morphological dependence of the number ratios of various SN types, using a large sample of SNe along with information about magnitudes, sSFR, and metallicities of their spiral host galaxies. Our sample of 692 nearby SNe ($\leqslant$ 97 Mpc) within 608 host galaxies is selected from the database of SNe and their host galaxies presented in Hakobyan et al. (2012).

As can be seen from the left panel of Fig. 1, there is a strong trend in behavior of $N_{\rm Ia}/N_{\rm CC}$ depending from host galaxy morphological types, such that early-type spirals include proportionally more Ia SNe. To demonstrate the relation between $N_{\rm Ia}/N_{\rm CC}$ and sSFR, in the left panel of Fig. 1 we have also shown the distribution of 1/sSFR according to the morphologies of the host galaxies. The best-fit sSFR values are extracted for host galaxies of 253 SNe available from the SDSS. Again, as for $N_{\rm Ia}/N_{\rm CC}$, there is strong trend for the distribution of 1/sSFR, such that sSFR of host galaxies systematically increased from early- (high-mass/luminosity) to late-type (low-mass/luminosity) spirals. Here, we share the view with Boissier & Prantzos (2009) that massive (early-type) spirals have, on average, lower sSFR. Therefore, the behavior of $N_{\rm Ia}/N_{\rm CC}$ versus morphology is simply reflection of the behavior of 1/sSFR versus morphological types of galaxies.

The right panel of Fig. 1 presents the distribution of $N_{\rm Ibc}/N_{\rm II}$ versus host morphology. The distribution is mostly flat and shows no dependence from the morphological types. However, when we divide the host sample into two broad morphology bins, i.e., S0/a–Sbc and Sc–Sm, the difference between number ratios in these bins becomes barely significant. The trend is same for $N_{\rm Ic}/N_{\rm Ib}$, such that early-type spirals include proportionally more type Ic than type Ib SNe. Thus, we have seen that $N_{\rm Ibc}/N_{\rm II}$ and $N_{\rm Ic}/N_{\rm Ib}$ ratios show weak variation with morphology of hosts.

In general, the $N_{\rm Ibc}/N_{\rm II}$ depends on metallicity, age, and fraction of binary systems (Eldridge et al. 2008). To qualitatively present relation between this ratio and metallicity, we extracted the best-fit metallicities available only for 196 CC SNe host galaxies from the SDSS. In the right panel of Fig. 1, we presented metallicity values in the fixed morphology bins by grey rectangles. Here, we have seen that metallicity show no or

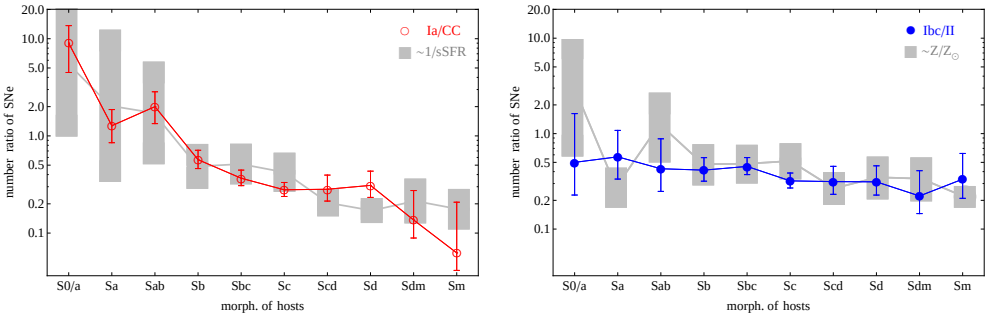

Figure 1. Relative frequency of SNe types as a function of host morphology. The $N_{\rm Ia}/N_{\rm CC}$ is presented by red open circles (left), while the $N_{\rm Ibc}/N_{\rm II}$ is presented by blue filled circles (right). The distributions of 1/sSFR (left) and $Z/Z_{\odot}$ (right) are presented by grey rectangles and shifted towards the vertical axis to visually fit the $N_{\rm Ia}/N_{\rm CC}$ and $N_{\rm Ibc}/N_{\rm II}$ distributions, respectively.

low variation with morphology of spiral hosts. Therefore, the behaviors of $N_{\rm Ibc}/N_{\rm II}$ and $N_{\rm Ic}/N_{\rm Ib}$ ratios versus morphology can be interpreted by simple reflection of the behavior of metallicity versus morphological types of spirals.

From our results, it is also clear that the $N_{\rm Ia}/N_{\rm CC}$ is higher for brighter galaxies. The result is in agreement with that of Boissier & Prantzos (2009): the brighter, i.e., high mass, galaxies host proportionally more Ia than CC SNe. In both cases, the results are not highly significant. The $N_{\rm Ibc}/N_{\rm II}$ and $N_{\rm Ic}/N_{\rm Ib}$ ratios are higher in brighter galaxies. These results are similar to $N_{\rm Ibc}/N_{\rm II}$ versus $M_{\rm B}$ relations obtained in Boissier & Prantzos (2009). Here, we agree with their interpretation: with increasing of luminosity (metallicity), the stellar envelope is more easily lost and lower mass stars may become type Ibc (Ic) SNe, increasing thus the $N_{\rm Ibc}/N_{\rm II}$ ($N_{\rm Ic}/N_{\rm Ib}$) ratio.

It is also evident that despite the degree of subjectivity involved in the morphological classifications, the number ratio-morphology relation is probably tighter than the number ratio-luminosity (metallicity) relation (according to significance values). The morphology that we have done in Hakobyan et al. (2012) using RGB images of the SDSS, i.e., considering to some extent also the color of galaxies, is more directly related to stellar population than the indirectly estimated metallicity. In particular, 64% of type Ia SNe are located in S0/a–Sbc galaxies in contrast to 40% of CC SNe. The mean morphological subtype of spiral hosts of Ia SNe is significantly earlier than those of all types of CC SNe hosts, and can be interpreted as the main factor constraining sSFR and metallicity of the progenitor populations. The complete study will be presented in Hakobyan et al. (2014).

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