Evidence for two distinct populations of type Ia supernovae

Type Ia supernovae (SNe Ia) have been used as "standard candle" to measure extragalactic distance and have led to the discovery of accelerating expansion of the universe which was awarded the 2011 Nobel Prize in Physics. However, it is embarrassing that their physics and progenitor systems remain elusive till today. SNe Ia are believed to be the results of thermonuclear explosions of white dwarf stars close to the critical Chandrasekhar mass limit. Theoretically, the exploding white dwarf can reach that mass limit by either merging with another white dwarf (DD) or continuous accretion from a companion (SD). These two different scenarios imply that progenitor stars should vastly differ in age, metallicity, and circumstellar environment. The progenitor systems can be probed by analyzing their spectral properties and comparing them with the birth environments such as locations and surface brightness within host galaxies. Funded by NSFC, researchers from Tsinghua University have shown that SNe Ia with low and high expansion velocities of the ejecta have different birthplace environments and are perhaps fundamentally different from each other. This work has recently been published in *Science* (**2013**, 340: 170—173).

Based on a large dataset of well-observed SNe Ia accumulated in recent years, researchers from Tsinghua university discovered that the SNe Ia can be grouped into two distinct classes, according to the ejecta velocities measured around the maximum brightness. Those with high-velocity ejecta are substantially more concentrated in the inner regions of their host galaxies than are normal-velocity counterparts (Figure). Furthermore, the former tend to inhabit larger and more-luminous hosts. These results suggest that high-velocity SNe Ia are associated with more metal-rich and perhaps younger stellar systems than normal-velocity SNe Ia, and are restricted to galaxies with substantial chemical evolution.

This research reveals for the first time that there are two distinct populations of type Ia supernovae, inconsistent with the popular interpretation with a SD model and a projection effect. The high-velocity features are perhaps formed due to the density increase caused by interactions of the supernova ejecta with the material around the exploding white dwarf, which could be an accretion disk or a filled Roche lobe. The angular variations in observing such an interacting system may explain the variation of the polarisation of the light and its correlation with the ejecta velocity for high-velocity supernovae. Thus, the high-velocity SNe Ia are likely from a single white dwarf accreting matter from companion stars, whereas the normal-velocity subclass are likely from both channels because of a geometric effect. This finding may bring an impact to current cosmological inference from type Ia supernovae, as the relative fraction of the high-velocity and normal-velocity populations is expected to change with redshift.

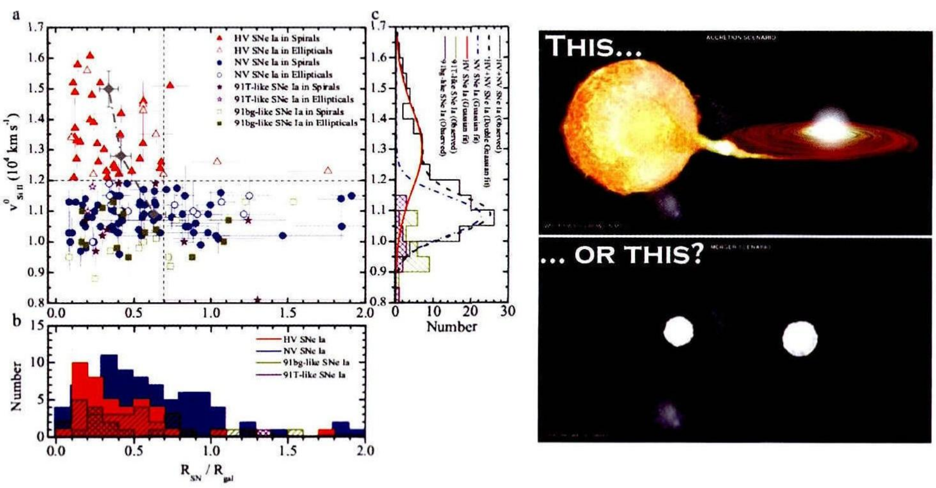

Figure Left: Radial distribution of SNe Ia of different subclasses in host galaxies. The blueshifted velocity inferred from Si II 6355 absorption is used to divide the sample into the high-velocity and normal-velocity subclasses (e. g. at 12000 km/s). Right: the mass-accreting and merging models of SN Ia progenitor systems.