Three-Dimensional Structure of Supernovae Studied by Spectropolarimetric Observations

TANAKA, Masaomi (NAOJ)
KAWABATA, Koji (Hiroshima University)
HATTORI, Takashi (NAOJ)
MAZZALI, Paolo A. (Max-Planck Institut für Astrophysik)
AOKI, Kentaro, IYE, Masanori (NAOJ)
MAEDA, Keiichi, NOMOTO, Ken'ichi (University of Tokyo)
PIAN, Elena (INAF-Trieste)
SASAKI, Toshiyuki (NAOJ)
YAMANAKA, Masayuki (Kyoto University)

Massive stars are thought to end their lives as supernova explosion. However, the explosion mechanism is not yet clear. Recent numerical simulations suggest that multi-dimensional effects are critical for successful explosions. In contrast, it is not easy to study the multi-dimensional shape of supernovae observationally, since supernovae in external galaxies are point sources (Figure 1).

In this study, we focus on spectropolarimetric observations, which are sensitive to multi-dimensional shape of the sources. We have performed multi-dimensional radiative transfer simulations and found following. (1) If the supernova explosion is completely axisymmetric, the spectropolarimetric data should align in the Stokes *QU* diagram. (2) If the supernova explosion has a 3D, clumpy structure, the data in the *QU* diagram show a loop. Based on these expectations, we have performed spectropolarimetric observations of extragalactic supernovae using Subaru/FOCAS.

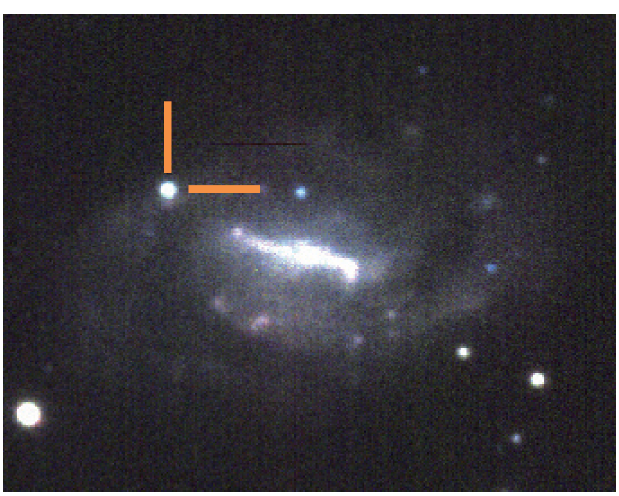

Figure 1: Optical image of SN 2009mi in IC 2151 (the position of the supernova is pointed by the lines).

As a result of spectropolarimetric observations [1], we found that the data show a loop in the *QU* diagram as shown in Figure 2. This is consistent with the expectation of a 3D, clumpy explosion. By combining our new results with our past observations [2,3] and the data taken by other groups, we found 5 supernovae out of 6 objects show a similar pattern. This indicates that supernova explosion generally has a 3D, clumpy structure. Such a structure may be formed by the convection during the explosion. Our results can be an important key to understand the explosion mechanism from actual observations.

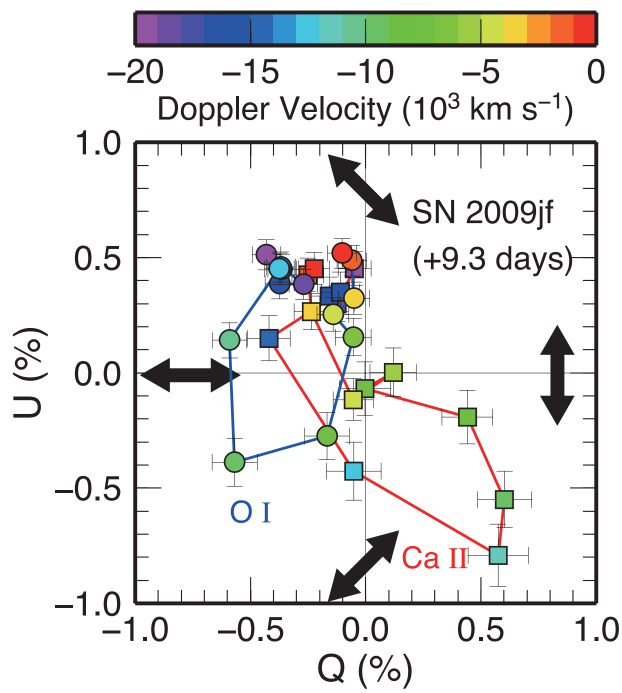

Figure 2: Spectropolarimetric data of SN 2009jf taken with Subaru/FOCAS. The data are plotted in the Stokes *QU* diagram. Different colors represent different wavelength (Doppler velocities). The observed data suggest 3D, clumpy structure of supernova ejecta.

References

[1] Tanaka, M., et al.: 2012, *ApJ*, **754**, 63.
[2] Tanaka, M., et al.: 2008, *ApJ*, **689**, 1191.
[3] Tanaka, M., et al.: 2009, *ApJ*, **699**, 1119.