Explosive Lithium Production in the Classical Nova V339 Del

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Lithium (Li) is a key element in the study of the chemical evolution of the universe because it likely has been produced by Big Bang nucleosynthesis,interactions between energetic cosmic rays and interstellar matter, evolved low-mass stars, novae, and supernova explosions. The observed Li evolutionary curve has a plateau for young Galactic ages (< 2.5 Gyr) followed by a steep rise. This indicates that a relatively low-mass stellar component is a major source of Li in the recent universe [1]. Some low-mass evolved stars have indeed been found to have Li-enriched surfaces. However, such Li could be easily depleted by convection in stellar surface and envelope, because Li should be destroyed inside stars where temperature is higher than 2.5 million K. Nova eruptions, which have evolved from low-mass binaries, are also assumed to be candidates for Li suppliers. No direct evidence, however, for the supply of Li from evolved stellar objects to the Galactic medium has yet been found. The origin of Li and its production process have long been an unsettled question in cosmology and astrophysics.

We have provided the first direct evidence to solve this question by spectroscopic observations of a classical nova [2]. The post-outburst spectra of V339 Del (=Nova Delphini 2013) were obtained using the high dispersion spectrograph (HDS) of the 8.2-m Subaru Telescope at four epochs (+38, +47, +48, and +52 days after the maximum). These spectra contain a series of broad emission lines originating from neutral hydrogen and other permitted transitions of neutral or singly ionized species (e.g., Fe II, He I, Ca II). Most of these broad emission lines are accompanied by sharp and blue-shifted multiple absorption lines at their blue edges (v_{rad} ~ $-1000\,km\,s^{-1}$). Among these absorption line systems, we have noticed two remarkable pairs of absorption features in the UV range near 312 nm. These correspond to the absorption components originating from the resonance doublet lines of a singly ionized radioactive isotope of beryllium, ^{7}Be. Figure 1 displays the blue-shifted absorption line systems of Hη, Ca II K, and the ^{7}Be II doublet in the spectrum obtained at +47 day. After ruling out the possibilities of alternative identifications, we concluded that these absorption features at 312 nm are caused by ^{7}Be.

Our spectroscopic detection of ^{7}Be in a classical nova immediately connects to the production of ^{7}Li. The production of ^{7}Be via the nuclear reaction $^{3}He(\alpha,\gamma)^{7}Be$ in novae has been studied theoretically [3]. Furthermore, the ^{7}Be absorption lines are found in highly blue-shifted flows. This means that it will soon decay to ^{7}Li in cooler interstellar or circumstellar matter on a time scale given by the half-life of ^{7}Be (53.22 days). The ^{7}Be abundance in the absorbing gas system estimated from the strengths of their absorption lines is perhaps 3–10 times as much as models predict. Since V339 Del appears to be one of the ordinary classical novae, the ^{7}Be production found in this object might be occurring in many classical novae. In near future, more observations of other nova explosions will provide much clearer model of Li evolution.

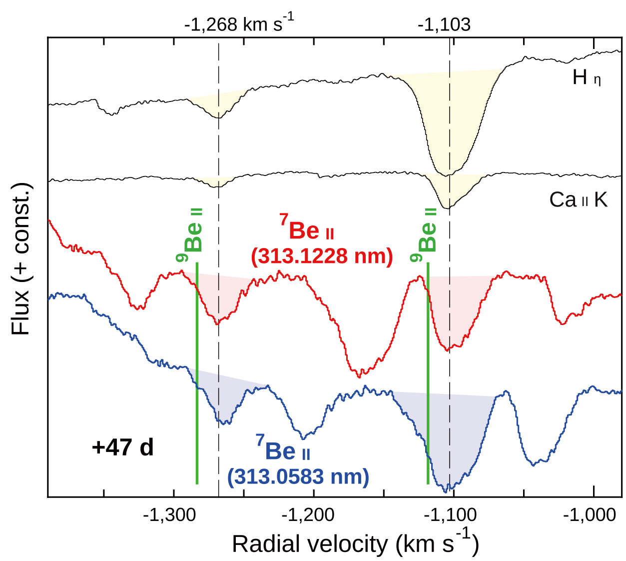

Figure 1: The blue-shifted absorption line systems in +47 days. All lines have two components of velocities at −1268 and −1103 kms^{-1}. Thanks to the high resolution of the spectrum (~ 0.0052 nm), we can clearly distinguish them from the doublet of ^{9}Be II at 313.0422 and 313.1067 nm (green lines).

References

[1] Prantzos, N.: 2012, *A&A*, **542**, A67.
[2] Cameron, A. G. W., Fowler, W. A.: 1971, *ApJ*, **164**, 111.
[3] Tajitsu, A., et al.: 2015, *Nature*, **518**, 381.