Faint Population III supernova as the origin of the most iron-poor stars

Chiaki Kobayashi[1], Miho N. Ishigaki[2], Nozomu Tominaga[3], Ken'ichi Nomoto[2]

[1] School of Physics, Astronomy and Mathematics, Centre for Astrophysics Research, University of Hertfordshire, Hatfield, UK (Arial, 14pt, italic, left-align)
[2] Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo, Kashiwa, Japan
[3] Department of Physics, Faculty of Science and Engineering, Konan University, Kobe, Japan

The most iron-poor stars in the Milky Way provide important observational clues to the astrophysical objects that enriched the primordial gas with heavy elements [1]. Among them, the recently discovered iron-deficient star SMSS J031300.36-670839.3 shows a remarkable chemical composition with non-detection of iron ([Fe/H]< −7.1) and large enhancement of carbon and magnesium relative to calcium. We investigate supernova yields of metal-free (Population III) stars to interpret the abundance pattern observed in this star. We report that the high [C/Ca] and [C/Mg] ratios and upper limits of other elemental abundances are well reproduced with the yields of core-collapse supernovae (that have normal kinetic energies of explosion E of E_{51} = E/10^{51}erg= 1) and hypernovae ($E_{51} \geq 10$) of Population III 25Msun or 40Msun stars. The best-fit models assume that the explosions undergo extensive matter mixing and fallback, leaving behind a black hole remnant. In these models, Ca is produced by static/explosive O burning and incomplete Si burning in the Population III supernova/hypernova, in contrast to the suggestion that Ca is originated from the hot-CNO cycle during the presupernova evolution. Chemical abundances of four carbon-rich iron-poor stars with [Fe/H]< −4.5, including SMSS J031300.36-670839.3 are consistently explained by the faint supernova models with the ejected mass of 56Ni less than 10−3Msun [2].

[1] K. Nomoto, C.Kobayashi, N. Tominaga 2013, Annual Review of Astronomy and Astrophysics, 51, 457
[2] M. Ishigaki, N. Tominaga, C. Kobayashi et al. 2014, Astrophysical Journal Letter, submitted (astro-ph/1404.4817)