Effect of Interstellar Objects on Metallicity of Population III Survivors Formed in a Cosmological Model

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We investigate metal pollution onto the surface of low-mass population III stars (Pop. III survivors) via interstellar objects (ISOs) floating in the Galactic interstellar medium. Only recently, Tanikawa et al. analytically estimated how much metal should collide to an orbiting Pop. III survivor encouraged by the recent discovery of 'Oumuamua [1] and suggested that ISOs are the most dominant contributor of metal enrichment of Pop. III survivors [2]. When we consider a distribution of interstellar objects in the Galactic disk, Pop. III survivors' orbits are significant properties to estimate the accretion rate of them though Tanikawa et al. assumed one modeled orbit. To take more realistic orbits into calculating the accretion rate, we use a high-resolution cosmological N-body simulation that resolves dark matter minihalos [3]. Pop. III survivors located at solar neighborhood have a number of chances of ISO($>$ 100 m) collisions, typically 5×10^6 times in the last 5 Gyr, which is one order of magnitude greater than estimated in the previous study. When we assume a power-law parameter α of the ISO cumulative number density with size greater than D as $n \propto D^{-\alpha}$, $0.80 M_\odot$ stars should be typically polluted [Fe/H]~ -2 for the case of $\alpha = 2.0$. Even in the cases of 0.70 and $0.75 M_\odot$ stars, the typical surface metallicity are around [Fe/H]$= -6 \sim -5$. From the presence of stars with their [Fe/H], we can constrain on the lower limit of the power α, as $\alpha \gtrsim 2.0$, which is consistent with α of km-size asteroids and comets in the solar system [4, 5, 6]. Furthermore, we provide six candidates as the ISO-polluted Pop. III stars in the case of $\alpha \sim 2.5$. Metal-poor stars so far discovered are possible to be metal-free Pop. III stars on birth.

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