New footprints of the Gaia-Sausage-Enceladus galaxy found in the LAMOST survey

Merging is an important process during the formation and evolution of galaxies and structures in the Universe. The massive ancient merger event of the Gaia-Sausage-Enceladus (GSE) has significantly reshaped our Galaxy.

Recently, a research group led by Prof. Gang Zhao from the National Astronomical Observatories, Chinese Academy of Sciences, found two footprints of the GSE merger event [1], and detected for the first time a metal-rich component with a low-alpha ratio in the LAMOST survey [2,3]. Despite young ages, the debris stars can reach 3-8 kpc above the Galactic plane, with a low-alpha ratio challenging the previously-thought splash process of the GSE merger event that happened in ancient times. Based on a hydro-dynamical simulation, Amarante et al. [4] proposed a new solution to the existence of metal-rich Sausage-kinematic (MRSK) stars with both high-alpha and low-alpha ratios. Meanwhile, Zhao and Chen [1] detected a feature in the eccentricity- $Z_{\max}$ diagram where a pile-up of MRSK stars at $Z_{\max}=3-5$ kpc significantly contributes to the formation of the disk-halo transition at $|Z|=4$ kpc, an interesting imprint left by the GSE merger event. This work provides new evidence for the scenario presented by Helmi et al. [5] that the GSE merger led to the formation of the Galactic inner halo and the thick disk.

The crash of the GSE galaxy into the inner Galaxy is currently a hot topic in the frontier of astrophysics. This work presents new observational constraints on the picture of the GSE merger event, in the chemical ($[\text{Fe}/\text{H}]-[\alpha/\text{Fe}]$) and orbital (ecc.- $Z_{\max}$) spaces. In particular, the detection of the metal-rich component of the GSE galaxy is consistent with the metallicity distribution of the Virgo Overdensity, thus connecting it to the distant Virgo Radial Merger (VRM) found at 15-25 kpc. The future 2-m Chinese Space Survey Telescope (CSST) has great advantages in the systematic search for the GSE/VRM debris in a huge volume of the sky. This work is the start-up of this project, and opens a door to reconstructing the Galaxy's merger history via the coming CSST.

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