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The 9th Magnitude CEMP star BD+44°493: Origin of its Carbon Excess and Beryllium Abundance

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Abstract. We performed a chemical abundance analysis of the very bright ($V = 9.1$) carbon-enhanced metal-poor (CEMP) star BD+44°493, which is the first star found with metallicity [Fe/H] < -3.5 and an apparent magnitude $V < 12$. The star is classified as a CEMP-no" subgiant, and its abundance pattern implies that a first-generation faint supernova is the most likely origin of its carbon excess. We set an very low upper limit on this star's beryllium abundance, which demonstrates that high C and O abundances do not necessarily imply high Be abundances.

Keywords. stars: abundances, stars: individual(BD+44°493), stars: Population II

1. Observation and Analysis

High-resolution spectroscopy of BD+44°493 was carried out with Subaru/HDS covering 3100-9350 Å with a resolving power of $R \sim 90,000$. The S/N ratio per pixel achieved was ~ 100 at 3100 Å and ~ 400 at 4500 Å.

The atmospheric parameters that we adopt are the effective temperature $T_{\rm eff} = 5510\,{\rm K}$, and the surface gravity $\log g = 3.7$. Our 1D LTE abundance analysis derives $[{\rm Fe/H}] = -3.7, [{\rm C/Fe}] = +1.3, [{\rm O/Fe}] = +1.6$ and $[{\rm Ba/Fe}] = -0.6$, indicating that this star is a carbon-enhanced metal-poor (CEMP) star. See Ito *et al.* (2009) for detail.

2. Origin of Its Carbon Excess

Among CEMP stars, some have excesses of *s*-process elements as well as carbon ("CEMP-*s*") while others do not ("CEMP-no"). Most of CEMP-no stars are found at lowest metallicity, suggesting the origin of CEMP-no stars is related to nucleosynthesis in first-generation stars. No excess of neutron-capture elements (e.g. Ba) found in BD+44°493 indicates that it is also classified as a CEMP-no star. We investigate the following three suggested scenarios to identify the origin of the C excess in this star.

First, mass transfer from a companion asymptotic giant branch (AGB) star, which has had great success in explaining CEMP-*s* objects, is not favored for BD+44°493. The first problem is that the neutron-capture elements, such as Ba and Pb, that are expected to be enhanced by an AGB companion are not over-abundant. Another constraint is the low C/O ratio (C/O < 1) found for BD+44°493, which cannot be explained by the AGB nucleosynthesis scenario (Nishimura *et al.* 2009). Moreover, radial velocity monitoring from 1984 to 1997 did not find any characteristic binarity signature (Carney *et al.* 2003).

Second, mass loss from rapidly-rotating massive stars (Meynet *et al.* 2006) is also not plausible. In this scenario, the N excess is predicted to be quite large due to operation of the CNO cycle in the H-burning shell. However, the observed N abundance of BD+44°493 ([N/Fe] = 0.3) is much lower than the prediction.

Third, so-called "faint" supernova associated with first-generation stars that produces less Fe and leads high [C/Fe] (e.g., Tominaga *et al.* 2007) is the most promising. Indeed, a faint supernova model reproduces the abundance pattern of BD+44°493 (Ito *et al.* in preparation).

3. Implications of the Beryllium Abundance

Thanks to its brightness, our high-quality UV spectrum allows inspection of the strength of the Be II lines at 3130 Å for BD+44°493, permitting measurement of a meaningful upper limit for Be at the lowest metallicity yet achieved ($A(\mathrm{Be}) = \log(\mathrm{Be/H})+12 < -2.0$). This is the lowest Be abundance limit so far for metal-poor dwarfs or subgiants that have normal Li abundances. The result indicates that the decreasing trend of Be abundances with lower [Fe/H], which was revealed by previous studies (e.g., Boesgaard *et al.* (1999)), still holds at $[\mathrm{Fe/H}] < -3.5$ (Fig. 1). It is consistent with the prediction of standard Big Bang nucleosynthesis models that produce little Be.

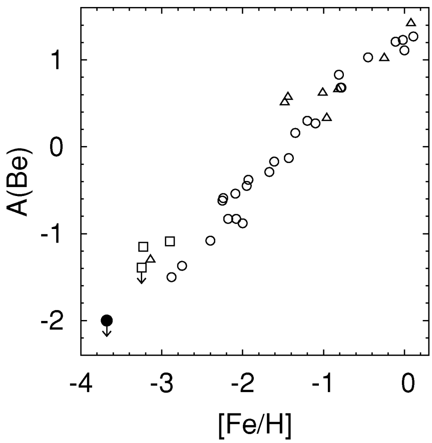

Figure 1. A(Be) vs. [Fe/H]. Our result for BD+44°493 is shown by the filled circle.

Our analysis is the first attempt to measure a Be abundance for a CEMP star. Since Be is produced via the spallation of CNO nuclei, their abundances, especially O abundances, have been expected to correlate with Be abundances. However, our low Be upper limit shows that the high C and O abundances in BD+44°493 are irrelevant to its Be abundance, which offers a new insight into the origin of CEMP-no stars.

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