GHOST SV Observation Evaluation Form

Title: Investigating the chemistry of the ultra-faint satellites Bliss 1 and Crater 2

Program ID: GS-2023A-SV-105

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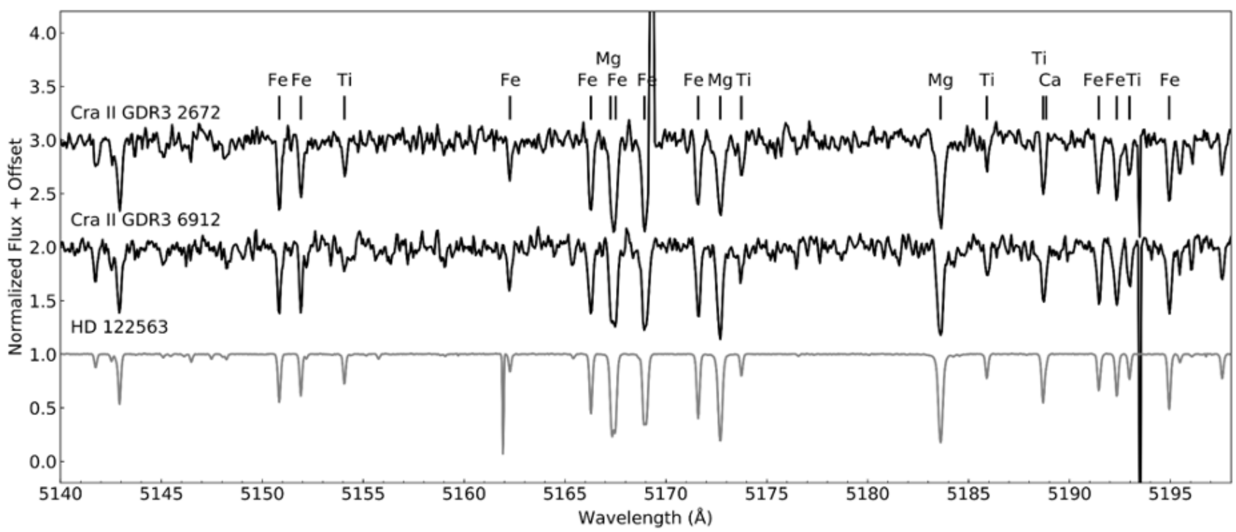
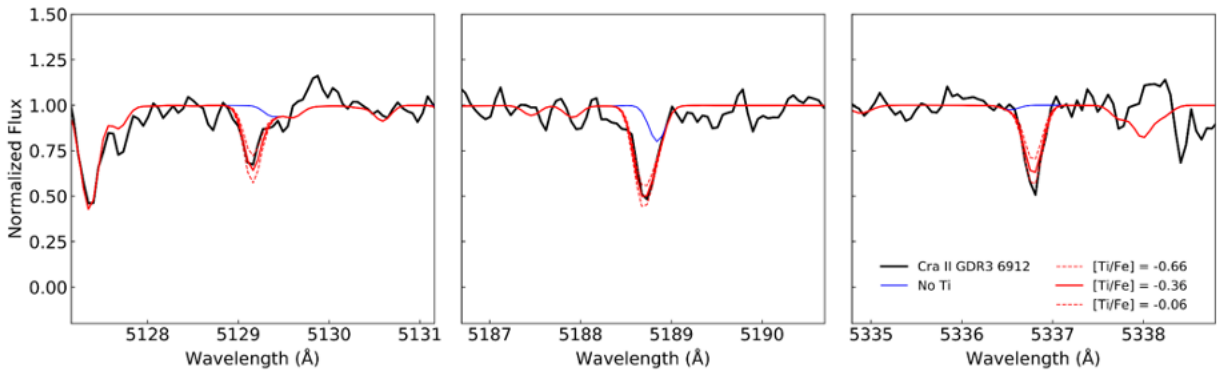
Description of the primary goals and the main findings

Crater 2 is an unusual dwarf galaxy because of its large size and relatively small velocity dispersion. While these features would normally imply that it is being tidally disrupted, conventional ΛCDM modeling suggests that tidal evolution alone cannot completely reproduce the observed size and velocity dispersion of Crater 2 (Errani et al. 2022). In addition Crater 2 lies at the division between ultra faint dwarf galaxies (UFDs) and classical dwarf spheroidal galaxies (dSphs) with an absolute magnitude of $M_V \sim -8$. Unlike most UFDs, Crater 2 shows evidence for multiple distinct episodes of star formation (Walker et al. 2019) with two clear main sequence turn-offs at ~ 12.5 and 10.5 Gyr.

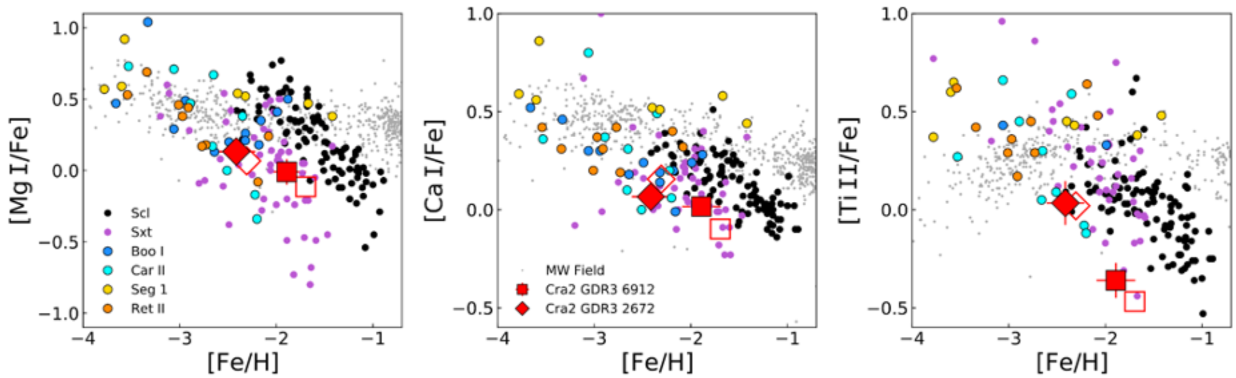
A ~ few Gyr gap in star formation is enough time for Type Ia supernovae to occur and pollute the galaxy with Fe-peak elements. Measuring the chemical abundance ratios of stars in Crater 2 then allows us to 1) look for the chemical signatures of Type Ia SNe and 2) gauge its chemical evolution history and rate of enrichment, which is correlated with galaxy mass and can begin to indicate whether Crater 2 should have been more massive in the past than it is today.

Below are some examples of the GHOST spectra of the two observed Crater 2 stars (which have been normalized and RV corrected) compared to the metal-poor benchmark giant HD 122563, and an example of some of the chemical abundance measurements that we can make with the GHOST spectra for one of the stars.





Measuring multiple elements lets us compare the ratios of different families of elements such as α-elements (tracing core collapse SNe products) and Fe-peak elements (tracing Type Ia SNe products). From the [α/Fe] ratios of three α-elements, Mg, Ca, and Ti, we can see that the [α/Fe] ratios are around solar ([α/Fe] = 0) as seen below, for these higher metallicity Crater 2 stars, which suggests that they have been enriched by Type Ia SNe.



Compared to other dwarf galaxies these solar [α/Fe] ratios are at the low end of what is seen in UFDs (e.g., Bootes I, Carina II, Segue 1, and Reticulum II shown above) and are more similar to the [α/Fe] ratios seen at higher metallicities in classical dSphs (e.g., Sextans and Sculptor). This suggests that Crater II may have more in common with the chemical evolution of classical dwarf galaxies than UFDs.

Additional comments on GHOST performance:

There are no other high-resolution spectra for these stars available to compare to, but for some comparison the S/N achieved in the GHOST spectra is higher than similar observations (target brightness, exposure time, etc.) with GRACES and extends further to the blue, making more of the spectrum available.

2x8 binning works well in the standard resolution mode for single targets

Suggestions for improvements:

It would help to have instructions for how to best set a sky position for any IFUs that were being used for sky (instructions were available during SV, and they were helpful, so I imagine future user's may also find these instructions useful).

The final S/N per pixel in the ITC seems to only report the maximum S/N between neighboring orders when they overlap, rather than reporting the S/N of each of the orders, or the S/N of the combined orders, either of which might be more helpful for users.

Any additional comments about GHOST SV

In terms of observations, the quality of these data are good and useful for new science.