UV-VISIBLE SPECTRAL CHARACTERISTICS OF PRIMITIVE ASTEROIDS: LINKS TO HYDRATION HISTORY? Amanda R. Hendrix[1], Faith Vilas[1]. [1]Planetary Science Institute, Tucson, AZ (arh@psi.edu).

Introduction: Primitive classes of main belt asteroids and the Jupiter Trojan asteroids – namely those of the B, P, D and C-complex types [1][2] -- hold clues to solar system origin and possibly giant planet migration, and thus characterization of these types of targets is critical, and ***yet they remain mysterious due to a lack of spectral clues about their surface compositions***. Most compositional studies cover visible-near-infrared (VNIR) wavelengths, but for these low-albedo bodies, VNIR wavelengths are largely spectrally featureless. ***We utilize the more spectrally active and potentially diagnostic UV-visible region to characterize these important targets.***

Nearly all low-albedo asteroids (and certainly the brighter, more silicate-rich S-type asteroids) exhibit a UV absorption (or UV “drop-off”) at wavelengths shorter than ~0.5 µm, attributed to a strong ferric oxide intervalence charge transfer transition (e.g.,[3][4]). *The strength and position of this feature can be probed to understand the surface composition and the aqueous/thermal history of a body.*

Recent work has shown tantalizing differences, at UV-visible wavelengths, among the sub-classes of the primitive types of asteroids [5]; the C-complex subclasses B-, Cgh- and Ch-type asteroids showed varying strengths of the UV absorption, with the C-type asteroids having the strongest absorption and the B-types having weaker UV dropoffs. Meanwhile, the UV dropoff in spectra of Trojans is seen to be minimal [6][7]. This suggests possible differences in surface composition - perhaps related to iron content or differences in hydration history of these groups of primitive bodies. The weaker dropoff in the B-class and minimal dropoff in the Trojans may even suggest a heliocentric trend (though the number of observations available is still very low).

A very limited set of UV observations of low-albedo class main-belt asteroids have been made. Twelve B-class and C-complex targets were observed by *International Ultraviolet Explorer* (IUE). Ceres has been observed using *Hubble Space Telescope* Space Telescope Imaging Spectrograph (HST/STIS) [8], and HST/FOS observations of asteroids Oda (D-type) and Alauda (B-type) are present in the archive. HST/STIS spectra of 6 Trojan asteroids have been published [6].

We have expanded the small suite of UV observations of primitive asteroids by observing 4 additional targets in Cycle 30 with HST/STIS, with 2 more to come later in 2023. In this program, we sample primitive asteroids at a range of heliocentric distances and of different taxonomic types. Specifically, we observe two main-belt P-type and two D-type asteroids, as such targets have never been observed with STIS and will provide useful comparisons with existing data of other types of asteroids, especially since these bodies are at the outermost part of the main asteroid belt and could provide the "missing link" between UV spectral trends among primitive targets (C-complex and B-types) in the main belt, and the Trojans. Furthermore, we observe 2 B-class asteroids, to confirm their weaker UV absorption by obtaining much higher SNR on these targets than the early IUE spectra, and to ascertain whether an absorption near 250-270 nm is present in the spectra of these surfaces, as hinted at by IUE.

Background: When considering the UV-visible spectral characteristics of low-albedo class asteroids, a primary distinction of the rocky, silicate-rich S-types is their strong UV absorption edges near 0.4-0.5 µm. This UV absorption (for all asteroid types, not just S-types) is due to Fe-O charge transfer and is thus related to surface composition (e.g., Fe-bearing phyllosilicates and past aqueous alteration). The C-complex asteroids, including the B, Cgh and Ch types, are low albedo and presumably carbonaceous (e.g. [1][2]). Ch and Cgh asteroids exhibit an absorption band at 0.7 microns that is due to aqueous alteration (e.g. [9]). P- and D- type asteroids are present primarily in the outer main belt and tend to be spectrally reddish at VNIR wavelengths. Trojan asteroids are spectrally similar, at VNIR wavelengths, to P- and D-type asteroids and are typically subdivided into the 'red' and 'less-red' objects by their VNIR spectral shape.

Using the existing IUE dataset of 12 B-class and C-complex asteroids, [5] combined IUE data (plus the one HST/FOS observation of B-class asteroid Alauda) with ground-based spectra to show UV-visible composite spectra of the asteroids. Those authors showed that differences in UV-visible spectral signatures among these asteroids can be linked to surface composition, and they showed that differences between the C-complex asteroids and CM chondrites can be attributed to the additional presence of space weathering-derived opaques on the surface of the asteroids.

Hypothesis. The idea that hydrated minerals exhibit a stronger UV dropoff has been discussed in the literature since the 1980s (e.g. [10]) based on broad-band ground-based datasets such as the 8-color asteroid survey [11]. The presence of opaques, perhaps the result of space weathering, will result in less-red 0.2-0.4 micron spectra [4][5][12], but [4] showed that less steep

UV slopes can also result from a lack of aqueous alteration (and resulting Fe-O interactions).

This idea has never been tested or explored by going deeper into the UV with spectra. However, the results of [5], namely that **C's are generally redder than B's are generally redder than Trojans in the 0.2-0.4 micron region** (based on a small sample!), may be consistent with the idea that **surfaces that exhibit deeper/stronger UV absorptions host 1) more Fe and/or 2) have experienced more aqueous alteration**. We suggest that such a trend could be expected to be dependent upon heliocentric distance (accounting for target size/age), with *overall less-red/flatter UV-visible bodies at greater heliocentric distances*. So, if a surface has never been aqueously altered (either because of a lack of H_2O or because of a lack of heating required to drive interaction between H_2O and Fe) and/or is dominated by hydrocarbons (rather than Fe-phyllosilicates), it is not expected to have a steep UV dropoff, or perhaps has no UV dropoff at all.

To test our hypothesis, our targets cover a range of target diameters, taxonomic classes and heliocentric distance (in terms of semi-major axis). Table I shows our suite of targets and their diversity in spectral class and heliocentric distance. Importantly, UV observations of P and D class asteroids in the main belt have never been made, and such observations – especially when compared with other classes of low-albedo asteroids – could indicate important trends.

Results. Preliminary results indicate that the two D-type asteroids observed (1144 Oda and 279 Thule) and the one P-type observed so far (65 Cybele) show very little (or no) UV-dropoff. The one B-type asteroid observed so far (24 Themis) shows a UV dropoff. This could generally be consistent with a heliocentric trend in composition and/or aqueous alteration. We will compare with previous observations of these and similar types of asteroids, and also compare with spectral models.

References: [1] Tholen, D. J. (1989) *IN: Asteroids II; Proceedings of the Conference*, Tucson, AZ, Mar. 8-11, 1988 (A90-27001 10-91). Tucson, AZ, University of Arizona Press, 1989, p. 1139-1150 [2] Bus & Binzel (2002) *Icarus 158*, 146-177 [3] Feierberg et al. (1985) *Icarus 63*, 183 - 191 [4] Vilas, F. (1995) *Icarus 115*, 217-218 [5] Hendrix & Vilas (2019) *Geophys. Res. Lett., 46*. https://doi.org/10.1029/2019GL085883 [6] Wong et al. (2019) *Astron. J.* 157, 161 [7] Hume et al. (2022) *LPSC* abstract #2721 [8] Hendrix et al. (2016) *Geophys. Res. Lett*., 43, doi:10.1002/2016GL070240 [9] Vilas et al. (1996) *Icarus 124*, 262-267 [10] Vilas & Gaffey (1989) *Science* 246 [11] Zellner et al. (1985) *Icaru, 61*, 355 [12] Hendrix & Vilas (2006) *Astron. J.* 132, 1396-1404

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Table I. Targets observed in this campaign

Target	taxonomic type	semi-major axis (AU)
24 Themis	B	3.13
372 Palma	B	3.145
65 Cybele	P	3.43
143 Hilda	P	3.98
1144 Oda	D	3.75
279 Thule	D	4.27