The CM-like Composition of 269 Justitia.

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Introduction: Over roughly the past 10-15 years, our view of the formation locations of main-belt asteroids has been dramatically changed by recognition that there was likely an epoch of planetary migration early in Solar System history [1, 2].

Constraints and tests of these models are dependent upon robust ties between spectroscopic measurements and formation locations. For the low-albedo material that dominates the main belt, the conventional wisdom has long held, based on available information, that asteroids with steep spectral slopes (D-class asteroids but also most X-complex asteroids) were reasonable proxies for objects with transneptunian origins.

Concurrent with the dynamical studies, however, spectroscopic studies established that a range of compositions can be seen from 3-µm studies of low-albedo asteroids, and those compositions were not generally well-correlated to spectral slopes in the 1—2.5-µm region. Two large populations have been identified based on 3-µm spectra: The "Sharp Types" (ST) with spectra like CM and other hydrated carbonaceous chondrites, and the "Rounded Types" (RT) with spectra unlike what is seen in the meteorite collection [3,4]. The nature of the RTs (also called by other names in the literature: [4]) is still a matter of debate, but proposals include ammoniated and icy compositions [5] with origins among the TNOs [6,7]

203 Pompeja and 269 Justitia are the reddest known objects in the asteroid belt, with spectral slopes "similar to RR and IR-class objects" in the taxonomy for transneptunian objects (TNOs) [8]. Their bright 2022 apparitions provided an opportunity to test how well spectral slopes can serve as a proxy for origin location and/or, potentially, determine the hydrated composition of transported TNOs.

Observations: Pompeja and Justitia were observed using SpeX on the NASA IRTF in the long-wavelength cross dispersed (LXD) mode on 15 March and 29 June 2022, respectively. Data reduction, including thermal modeling, followed our usual practice [4,6]. We focus here on Justitia given that it was observed while brighter and in better observing conditions than Pompeja, and given reports of rotational variation on Pompeja [9] that may complicate simple, preliminary interpretations.

Results: A slope-removed spectrum of Justitia is shown in Figure 1. Justitia shows a clear ST spectrum, similar to numerous main-belt low-albedo asteroids. Also shown on Figure 1 is a slope-removed spectrum of CM2 Bells [10], with its contrast reduced by ~50% but no other changes. Its close visual match to the Justitia spectrum suggests that a CM-like composition is a reasonable interpretation and that no other compositional components (other than perhaps a neutral material) are present. We note that the prominent feature near 3.4 µm in the spectra can be attributed to aliphatic organic materials.

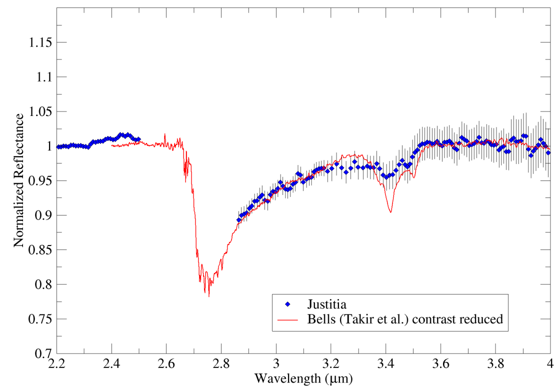

Figure 1: IRTF Spex spectrum of Justitia, and a spectrum of CM2 Bells from [10] for comparison. The Bells spectrum has been reduced in contrast.

Implications: We must reconcile the observations and our expectations. If the very red spectral slope of Justitia is an indication that it formed as a TNO, then the LXD data shows that at least some TNOs have experienced aqueous alteration and have compositions very similar to typical CM2 meteorites. If the CM2-like composition is a signal that Justitia did not form as a TNO, then this serves as additional evidence that spectral slope is not well-correlated to composition for low-albedo asteroids [6] and that we do not fully understand the origins of spectral slope in low-albedo materials. We look forward to additional measurements of D-class objects in the 3-µm region by the Lucy spacecraft and JWST to allow further comparisons to be made.

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