The nonlinear spectra of transneptunian objects: Evidence for organic absorption bands

W. Fraser[1,2], M. Brown[2], and J. Emery[3]

[1]Herzberg Institute of Astrophysics
[2]California Institute of Technology
[3]University of Tennessee

The reflectance spectra of small ($D \lesssim 250$ km) transneptunian objects (TNOs) are generally quite simple. Water-ice absorption is the only feature firmly detected on the majority of TNOs (Brown et al. 2012). Tentative detections of other materials have been presented (e.g., Barucci et al. 2011), but generally speaking, the spectra of small TNOs are nearly linear in the optical ($0.5 < \lambda < 0.9$ µm; Fornasier et al. 2009) and NIR ranges ($1.0 < \lambda < 1.5$ µm) with water-ice absorption apparent at longer wavelengths (Barkume et al. 2008). Each region is well described by a spectral slope, with the optical slope being typically redder than in the NIR (Hainaut and Delsanti, 2002, 2012). Here we present new spectral photometry of two TNOs which do not fit this simple prescription.

We will present photometry of TNOs taken from HST during cycles 17 and 18. Unlike most objects, two TNOs do not exhibit linear optical spectra. Rather, they exhibit upward curvatures shortward of $\lambda \sim 1$ µm, with colors becoming redder with increasing wavelength. Previously published spectra and photometry exhibit similar optical shapes on a number of TNOs, including Borasisi, Pholus, Chariklo, Asbolus, and 2003 AZ_{84} (Romon-Martin et al. 2002, Alvarez-Candal et al. 2008, Fornasier 2009, Hainaut and Delsanti 2012).

An interesting candidate for the upward curvature is complex C- and N-bearing hydrocarbons. These organic materials exhibit a broad absorption centered in the UV which is caused by a valence-conduction energy gap (see Moroz et al. 1998). The specific shape of the feature depends on the molecular structure of the organic material, with longer hydrocarbons generally producing wider absorptions. The assertion that the optical spectra of small TNOs are influenced by this hydrocarbon feature is reasonable as the feature is the general result of irradiation of simple organic H-, C-, and N-bearing materials, not dissimilar to that expected to occur on young TNOs (Brunetto et al. 2006).

The interpretation of this feature as an absorption due to organics is compatible with the conclusions of Fraser and Brown (2012) who found that the small dynamically excited Kuiper-belt objects exhibit two different compositional classes. They assert that the difference between the neutral and red classes are the result of mixing of a non-icy (likely silicate) material component with two different organic components, one for each class of object. Brown et al. (2011) argue that because there is no quantitative difference between the colors of Centaurs and more distant TNOs, the two separate organic components are not the result of recent surface evolution, but rather is caused by early, post-formation volatile loss from the TNOs. Irradiation then rapidly drove evolution along two separate chemical pathways between those objects that lost and those objects that retained their volatiles. If it is shown to be true that the source of TNO spectral shapes are due to hydrocarbons, then the shape of the feature, which spans the UV-NIR region, holds the potential to reflect the relative irradiation doses experienced in the early Solar System between different objects within the same compositional class of TNO, and hence inform us of their relative formation locations.

References: Alvarez-Candal et al. 2008, A&A 487..741A; Barkume et al. 2008, AJ, 135..55B; Brown et al. 2011, ApJ, 739L..60B; Brown et al. 2012, AJ, 143..146B; Brunetto et al. 2006, ApJ, 644..646B; Fornasier et al. 2009, A&A, 508..457F; Fraser and Brown. 2012, ApJ, 749..33F; Hainaut and Delsanti 2012, A&A, 546A.115H; Moroz et al. 1998, Icar., 134..253M; Romon-Martin et al. 2002, Icar., 160..59R; Schaller and Brown 2007a, ApJ, 659L..61S.