# SURFACE PROPERTIES OF EXTREME TNOs BASED ON HERSCHEL/PACS MEASUREMENTS: THE CASE OF SEDNA AND 2010 $EK_{139}$

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**Introduction**: Sedna is a prominent member of the detached objects in the trans-Neptunian population and often classified as an inner Oort-cloud object. Until now, no accurate measurements for the diameter and albedo are available for this object, only upper limits are known for its diameter [1,2]. 2010 $EK_{139}$ has recently been detected by a southern Galactic plane survey [3] and orbits the Sun on a rather elliptic and wide orbit and also a prominent dwarf planet candidate. Due to the extreme orbits of these objects, it is interesting to investigate the surface properties, focusing on the possible correlation found between the diameter and albedo of detached and scattered objects [4,2].

**Observations**: We observed Sedna and 2010 $EK_{139}$ with the PACS camera of the Herschel Space Observatory [5,6] in the framework of the "TNOs are Cool!: A survey of the trans-Neptunian region" Open Time Key Program (PI: Th. Müller, see also [7]). We obtained images acquired in mini scan map mode at the wavelengths of 70, 100 and 160 μm. The observations were performed in two visits, allowing a subtraction of background sources that would cause otherwise significant confusion noise. In total, Sedna and 2010 EK139 have been observed 3.14 and 1.26 hours, respectively.

**Data reduction and modeling**: In order to have a reliable estimation for the thermal fluxes, we developed an improved pipeline for PACS scan map reductions. The details of the data processing steps are detailed in the recent papers from the "TNOs are Cool!" team [4,8]. The absolute magnitudes for these objects were taken from literature [3,9] and in the case of 2010 EK139, we used MPC data for estimating the uncertainty. These magnitude values have been then combined with the PACS fluxes and used in the modeling of the spectral energy distributions. We employed the STM [10] and TPM techniques [11] to derive the geometric albedo and diameter and other surface properties (such as beaming parameter or thermal inertia).

**Results**: We obtained a diameter and albedo of D=995 +/- 80 km and pV = 0.32 +/- 0.06 for Sedna and D=470 +35/-10 km and pV = 0.25 +0.02/-0.05 for 2010 $EK_{139}$, respectively. Both objects have been found to have a brighter surface than the average TNO population, however, these albedo values agree with the previously estimated correlation in the detached objects [4]. Since Sedna seemingly lies in the region where volatiles are expected to be retained in the surface [12], one can also expect a brighter surface [12,13]. However, 2010 $EK_{139}$ is smaller than Sedna, and hence volatiles cannot be retained on its surface. The presence of water ice can also results in a brighter surface [14]. This is also indicated by a bluish intrinsic color [1], so further measurements of the V-R color index can verify this hypothesis.

It seems that although both of our objects discussed here can confirm the correlation between the albedos and diameters, it seems that the physics behind these observations are due to different mechanisms. Further observations of another extreme objects, for instance, 2010 $JJ_{124}$ [3] might confirm these results.

**References**: [1] Brown, M. E., 2008, The Solar System Beyond Neptune: The Largest Kuiper Belt Objects, p. 335. [2] Stansberry, J., et al., 2008, The Solar System Beyond Neptune, Physical Properties of Kuiper Belt and Centaur Objects: Constraints from the Spitzer Space Telescope, p.161. [3] Sheppard, S. S. et al. 2011, AJ, 142, 198 [4] Santos-Sanz, P., et al., 2012, A&A, accepted [5] Pilbratt, G., et al., 2010, A&A, 518, L1 [6] Poglitsch, A., et al., 2010, A&A, 518, L2 [7] Müller, T.G., et al., 2009, EM&P, 105, 209 [8] Mommert, M., et al., 2012, A&A, accepted [9] Rabinowitz, D. L., Schaefer, B. E. & Tourtellotte, S. M. 2007, AJ, 133, 26 [10] Lebofsky, L. A. et al. 1986, Icarus, 68, 239 [11] Lagerros, J. S. V. 1996, A&A, 315, 625 [12] Brown, M. E.; Burgasser, A. J. & Fraser, W. C 2011 ApJL, 738, 26 [12] Emery, J. P. et al. 2007, A&A, 466, 395 [13] Barucci, M. A.2005, A&A, 439, 1 [14] Dumas, C. 2011, A&A, 528, 105