Ice and refractories in the ambient coma of 103P/Hartley 2. S. Protopapa[1], J. M. Sunshine[1], L. M. Feaga[1], S. Besse[1], O. Groussin[2], F. Merlin[3], M. S. Kelley[1], J.-Y. Li[1], T. L. Farnham[1], M. F. A'Hearn[1] and the DIXI Team
[1]Department of Astronomy, University of Maryland, College Park, MD 20742, USA, [2]Laboratoire d'Astrophysique de Marseille, CNRS and Université de Provence, Marseille, France, [3]Université Paris 7, LESIA, Meudon, France.

Introduction: The Deep Impact eXtended Investigation (DIXI) to comet 103P/Hartley 2 culminated in a closest approach (CA) of ~700 km on November 4th, 2010, when the comet was at 1.064 astronomical units (AU) from the Sun [1]. The visit to comet Hartley 2 was conducted using the existing Deep Impact (DI) spacecraft [2], employing two multi-spectral imagers and a near-infrared (IR) spectrometer.

Observations: Spatially resolved near-IR spectra of comet Hartley 2 have been acquired in the wavelength range 1.05-4.85 μm using the High Resolution Instrument Infrared Spectrometer (HRI-IR) [3]. Data have been collected in the time interval between 01 October and 26 November 2010. In this paper only a subset of data is analyzed. In particular, we present HRI-IR spatially resolved scans of comet Hartley 2 collected 7 (ID 5006000) and 23 (ID 5007002) min post CA, with a spatial resolution at mid scan of 55 and 173 m/pixel, respectively. Both scans contain the nucleus of Hartley 2 and the surrounding coma. The nucleus presents roughly the same orientation in the two scans, this way having the possibility to provide two separate characterizations of the frozen volatiles and non volatiles in the ambient coma of Hartley 2.

Water ice rich vs water ice depleted regions: Comet Hartley 2 displays jets off the end of the smaller lobe of the nucleus and beyond the terminator along the lower edge of the larger lobe [1]. Spectra extracted in the coma of Hartley 2 are red-sloped (increasing reflectance with increasing wavelength). The red slopes are in general well reproduced by a refractory component (e.g amorphous carbon). Typical areas in the coma do not show significant absorption features, while the spectra extracted in the jet regions display clearly water ice absorption bands at 1.5, 2.0, and 3.0 μm [4]. We do not detect within our SNR the 1.65-μm absorption band linked to the presence of crystalline water ice. Crystalline ice indicates formation temperatures in excess of 130K or subsequent heating to above 130K [5]. The spectral variability of crystalline water ice with temperature in reflectance spectra indicates that the 1.65-μm band reduces in strength as temperature increases, and it almost disappears for T≥230K [5,6]. Therefore, the non detection of the 1.65-μm absorption band, if real, could indicate the presence of amorphous ice or ice in crystalline phase at T≥230K. The second possibility is highly improbable since at T=230K the sublimation of water ice is on the order of 10ˆ19 molecules/cmˆ2/sec, implying short lifetime for water ice grains. Another band strongly dependent on water-ice deposition temperature is the one near 3 μm. As observed in [6], this feature consists of one central component and two shoulders in the crystalline sample while the amorphous sample shows a single broad feature. The observed 3-μm band in Hartley 2 seems more compatible with amorphous water ice.

Modeling: A quantitative analysis of the Hartley 2 coma reflectance spectra is performed using the Hapke radiative transfer model. The spectra are well reproduced by a linear mixture of water ice with dark and featureless refractory component (e.g. amorphous carbon). The best fit modeling is obtained with particle diameters on the order of 1 μm for both components. Optical constants for amorphous and crystalline water ice at temperature of 120K and 150K, respectively, have been used. In the water ice rich regions, amorphous ice provides a better fit with respect to crystalline water ice. Using a linear mixing implies that water ice in the coma of Hartley 2 is relatively pure. Indeed the linear mixing assumes that each component is well separated from others. This is supported by temperature considerations: if water is in an amorphous state (T≤135K), as evidence indicates, it can not be in thermal equilibrium with the dust, which has temperature T ≥ 300K (black body temperature at 1 AU).

Spatial distribution of water ice: For each scan we retrieve an ice abundance map. Both maps confirm that the region of the jets off the end of the smaller lobe is richer in water ice with respect to the one emanating from beyond the terminator. A maximum water ice abundance of 15% and 6% is observed 7 and 23 min post CA, respectively. The spatial distribution of water ice is consistent with an outflow behavior within 2 km from the nucleus, indicating that water ice does not sublime or fragment at this scale.

References: [1] A'Hearn M. F. et al. (2011) *Science, 332,* 1396–1400. [2] A'Hearn M. F. et al. (2005) *Science, 310,* 258–264. [3] Hampton D. L. et al. (2005) *Space Science Reviews, 117,* 43–93. [4] Warren S. G. and Brandt R. E. (2008) *Journal of Geophysical Research (Atmospheres), 113,* 14220. [5] Grundy W. M. and Schmitt B. (1998) *Journal of Geophysical Research, 103,* 25809–25822. [6] Mastrapa R. M. et al. (2009) *The Astrophysical Journal, 701,* 1347–1356.