Comet Hartley 2: A Different Class of Cometary Activity. M. F. A'Hearn[1] and the DIXI Science Team, [1]Department of Astronomy, University of Maryland, College Park MD 20742 (ma@astro.umd.edu).

Introduction: The EPOXI mission is an extended mission for the Deep Impact Flyby spacecraft and comprises two independent scientific investigations – Extrasolar Planet Observation and Characterization (EPOCh) and Deep Impact eXtended Investigation (DIXI). The latter program was concentrated on a close flyby of comet 103P/Hartley 2 on 4 Nov. 2010. The target had been chosen with the goal of studying a cometary nucleus that was much smaller than those previously visited. Coincidentally, this comet was also one of the few short-period comets with outgassing so high for its size that equilibrium sublimation of dirty ice would require a very large active fraction for the surface. This presented the first opportunity ever to compare *in situ* two different cometary nuclei with the same instruments.

The instrument complement [1] includes a Medium Reolution Instrument (MRI) which is a visible-wavelength CCD imager with pixel scale of 10 μrad/pix and FOV of 10 mrad and with a set of interference filters for isolating cometary emission bands and reflected continuum. The spacecraft also carries a High-Resolution Instrument (HRI) that uses a dichroic beamsplitter feeding a visible-wavelength CCD with a scale of 2 μrad/pix and with interference filters spanning the optical regime for geological colors (HRI-Vis), and a near-infrared (1.05-4.85 μm) long-slit (10 μrad × 5 mrad) spectrometer (HRI-IR). During the encounter, roughly 125,000 "images" were taken, where the term images includes the individual, long-slit, near-IR spectral frames. Spectral maps were created by slewing the spacecraft such that the slit of the spectrometer moved across the comet, with exposures typically taken once per slit width of motion, although sometimes other rates were used.

The closest approach distance was 694 km, very similar to the closest distance at which images had been taken of comet 9P/Tempel 1 during the prime mission. Flyby speed was 12.3 km/s along a trajectory that was nearly along the terminator, with the phase at closest approach being 79.4°. Observations were made from 5 Sep to 26 Nov, *i.e.,* for two months on approach and for three weeks on departure, with varying cadences designed to optimze the study of the variations of the nucleus and its activity with orbital position and with rotational phase.

Preliminary Results: As expected whenever one makes measurements in a totally new regime, there were many surprises in the data. In a two-week period spanning full moon in September (so that very few Earth-based observations are available) there was a many-fold increase in CN with no corresponding increase in other species, particularly no increase in the solid grains responsible for scattered sunlight released to the coma [2]. This behavior has not been reported previously in any comet.

As shown in Figure 1, the nucleus itself is indeed far smaller than that of Tempel 1, even though it releases more water vapor per unit time than does Tempel 1. It has a bi-lobate shape that is rough on both lobes (Figure 2) but with relatively smooth (scales > several m) material in the waist where the two lobes are joined, the interpretation of which is still under discussion [3,4]. Studies of the rotational light curve on approach show that the dominant frequency is changing more rapidly than observed in any other comet [5], as confirmed by numerous Earth-based observers, *e.g.* [6]. There are also indications both from the rotational light curve [5] and the morphology of the coma structures [6,9] that the nucleus is not in principal-axis rotation, but rather in an excited rotational state.

The coma also showed a very strong signature of icy grains, apparently lifted from the nucleus by a relative excess of CO_2 emission. At the time of closest approach the dominant emission of CO_2 and icy grains was from the end of the more-sunward-pointing smaller lobe but they are also being lofted from the sides of the larger lobe (Figure 2) [7,8]. Spectral maps of the icy grains, the H_2O vapor, and the CO_2 vapor show very different spatial distributions suggesting that relatively pure H_2O is released from the smooth waist while CO_2 is released primarily from the rough areas, particularly the end of the smaller, sunward-facing lobe [8]. The same data show that there is a large quantity of uniformly distributed H_2O, presumably released by sublimation of the icy grains. The larger grains are moving very slowly with respect to the nucleus (< 2 m/s), are spatially close to the nucleus (10s of km), and extend in size up to tens of cm [10]. The extent of the mixing between ice and refractories is not yet determined.

Whether or not Hartley 2 is the prototype of a new class of comets is an interesting question to be investigated. This class of comets would have their water at perihelion come not primarily from sub-surface sublimation of H_2O ice as in Tempel 1 but from a halo of grains of H_2O ice that have been lofted by sublimation, presumed to be sub-surface, of CO_2.

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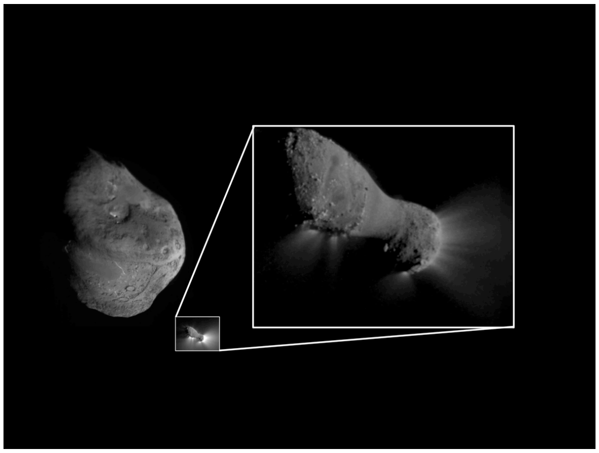

Figure 1: Comparison of the two nuclei studied with the Deep Impact Flyby Spacecraft to show dramatic differences in size and morphology.

Figure 2: The larger, more anti-sunward lobe of the nucleus, surrounded by grains, many of which are composed of H_2O ice.

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