CN COMA MORPHOLOGY OF COMET 103P/HARTRLEY 2 DURING THE 2010 APPARITION.

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Introduction: Comet 103P/Hartley 2 had a very close approach to Earth (perigee was at 0.12 AU on October 20, 2010) and NASA's EPOXI mission encountered the comet on November 4, 2010, about one week after perihelion (October 28, 2010). This rare occurrence was observable from the ground and is a unique opportunity to characterize a Jupiter-family cometary nucleus and its coma in unprecedented details.

Observations: We observed comet 103P/Hartley 2 at the Kitt Peak 2.1m telescope with the STA2 CCD with broadband R and narrowband comet filters ([1]) from September 1–3, September 30 to October 4, November 2–8, and December 11–15, 2010. The scale for the STA2 is $0.''305\,\mathrm{pixel}^{-1}$ and the field of view is $6.'5$ in the North-South direction and $10'$ in the East-West direction. The geometric circumstances of our observations are shown in Figure 1. We focussed on the R and CN filters as they provided images with the best signal-to-noise for deducing the coma morphology for dust and a gas species. However, images for the other gas species (OH, NH, C_3, and C_2) and continua images with the blue (BC) and green (GC) filters were also taken.

CN Coma Morphology: We concentrate here on the CN coma morphology and the implications for the spin state of comet 103P/Hartley 2. The unenhanced images show clear asymmetries in CN indicating structure in the coma. In order to increase the contrast for the structures above the overall coma, the images need to be enhanced. We used division by azimuthal average ([2], [3], [4]) to bring out the structure in the CN coma and the results were consistent with structure seen using different en-

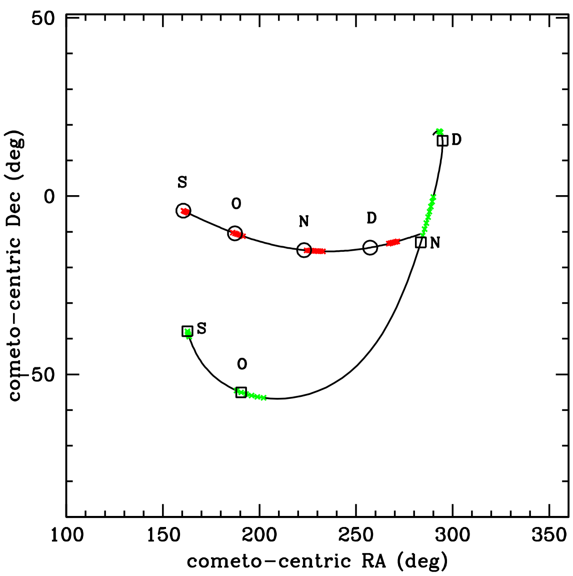

Figure 1: The directions to Earth (squares) and Sun (circles) in the cometocentric Earth mean equator and equinox of J2000 (EME2000) frame at 00:00 UT on the first day of September (S), October (O), November (N), and December (D). The directions to Earth and Sun during our four observing runs are shown with green × and red × respectively. The angular separations between the respective directions represent the corresponding solar phase angles for each observing run.

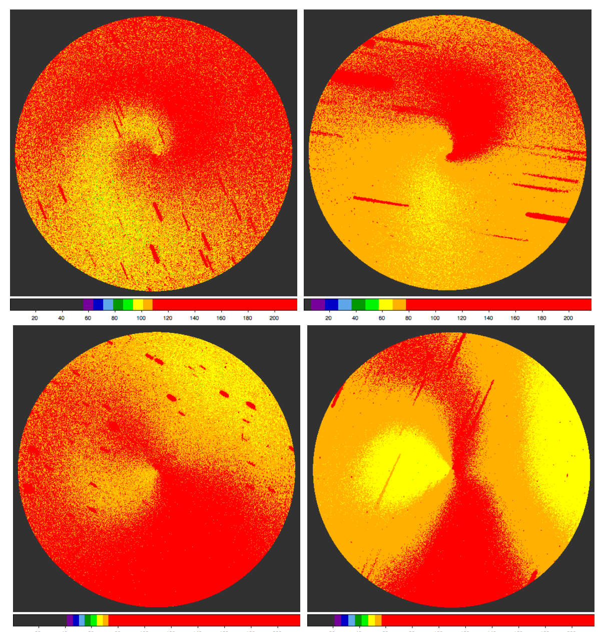

Figure 2: Enhanced CN images clockwise from top left for September 3 (06:18 UT), October 4 (06:50 UT), November 3 (09:56 UT), and December 11 (11:41 UT). North is up and East is to the left. Red denotes higher flux. The images were enhanced using division by azimuthal average. The nucleus (opto-center) is at the center of each image. The streaks are trailed stars.

hancement techniques. All the images were enhanced in the same way. A sample of enhanced CN images, one for each run, is shown in Figure 2. The images all have a radius of 500 pixels which translates to ≈42,000 km at the comet for the September run, ≈20,000 km for the October run, ≈18,000 km for the November run, and ≈39,000 km for the December run. Changes in the CN coma morphology could be seen during a single night, during a single run, and between our four observing runs.

Implications for the Rotation State: As was noted by us first ([5]) and subsequently confirmed by other observers, the rotation period of the comet is changing. A rotation period of 16.6 hours was deduced from the bare-nucleus lightcurves observed in 2009 ([6]), which is consistent with the periodicity deduced from CN coma morphology from August 2010 ([7]). We reported periodicities of 17.1 hours and 17.6 hours from CN coma morphology observed in early September and early October respectively ([5]). Radar observations from late October yielded a period of 18.1 hours ([8]) in agreement with the period derived from photometry ([9]). A much longer period is claimed from observations of HCN ([10]).

These changes in periodicity of at least one hour over a few months are rather large. Observed changes in the rotation periods of comets 10P/Tempel 2, 1P/Encke, and 9P/Tempel 1 are in the range of tens of seconds to tens of minutes per perihelion passage ([11], [12], [13], [14]). The large change in the periodicity of comet 103P/Hartley 2 is consistent with the high level of activity present ([15], [16], [17]) in this relatively small and elongated nucleus ([18], [19], [8]).

The presence of small differences in the CN morphology during some rotational cycles for image pairs having the same rotational phase is a strong indicator that the nucleus of comet 103P/Hartley 2 is in a non-principal axis spin state ([5]). Therefore, the term "rotation period" in this abstract should be interpreted to mean "the apparent best-fit rotation period". Any rotation state model for comet 103P/Hartley 2 will have to explain the extensive ground-based data, photometry, radar data, and the spacecraft images. During the meeting, we will report on our assessment of the changing spin state using our extensive data set ranging from September to December, 2010. Figure 3 shows our excellent rotational phase coverage for a sample period of 17.6 hours. As noted above, the rotation period is changing during our observing window, so figure 3 is only for illustration purposes to highlight the phase coverage.

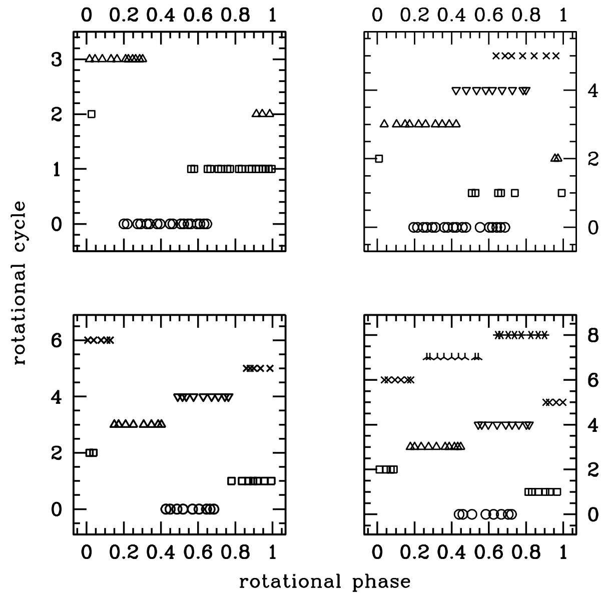

Figure 3: Phase plots clockwise from top left for a rotation period of 17.6 hr for our September, October, November, and December runs. Zero phase was arbitrarily chosen as 00:00 UT on the first night of each run. The different symbols correspond to different nights in an observing run.

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