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Optical monitoring of the coma of comet 103P/Hartley 2*

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Abstract

We present the results of coma monitoring of comet 103P/Hartley 2 at the epoch of the *EPOXI* encounter. The images were obtained using the 2 m telescope of the Bulgarian National Astronomical Observatory at Rozhen, in the bands of CN, C_3, C_2, and dust. All the three radicals formed very similar transient features which expanded outwards. Evolution of the CN structures was used to determine the sky-projected expansion velocities. Photometry of the CN coma shows strong variability, which we consider as caused by the nucleus rotation. The repeatability of the coma pattern was not perfect, which agrees with the suggested excitation of the rotation state.

1. Introduction

Given the very favourable orbit (perihelion at 1.06 AU and the orbital period of 6.47 years), comet 103P/Hartley 2 has been relatively well characterized prior the 2010 apparition, although no information about the nucleus rotation has been obtained. The knowledge about the rotation state is important for establishing the lifetime of comets, since one of the possible destruction mechanisms is disruption by centripetal force when the rotation is sufficiently fast.

EPOXI-based photometry [1], as well as ground-based observations [2, 3, 4] show, that during the last apparition the nucleus was rotating in excited mode and the period was increasing with time. The *EPOXI* results [1] suggest precession about the longest axis of inertia with the period of 18.34 h and roll about the shortest axis of inertia with the period of 27.79 h (both applicable at the encounter). The 2:3 resonance between precession and roll results in the best repeatability of the activity pattern every three precession cycles [1, 2].

* Based on data collected with 2-m RCC telescope at Rozhen National Astronomical Observatory.

2. Observations

We observed the comet on four nights: November 2, 4, 5, and 6, 2010 with the two-channel FoReRo2 focal reducer at the 2-m telescope of the Bulgarian National Astronomical Observatory (BNAO). The CN, C_3, C_2 radicals were observed at 387, 406, 512 nm respectively, and dust was monitored at 443 and 642 nm. CN was observed in long series while only snapshots were obtained for C_3, C_2, and dust.

3. Results and Discussion

To reveal transient structures in the coma we used a novel approach: Iterative Image Decomposition, which extracts the time-invariant coma profile, and produces a series of images for the residual, time-dependent component. Examples of such images are presented in Fig. 1.

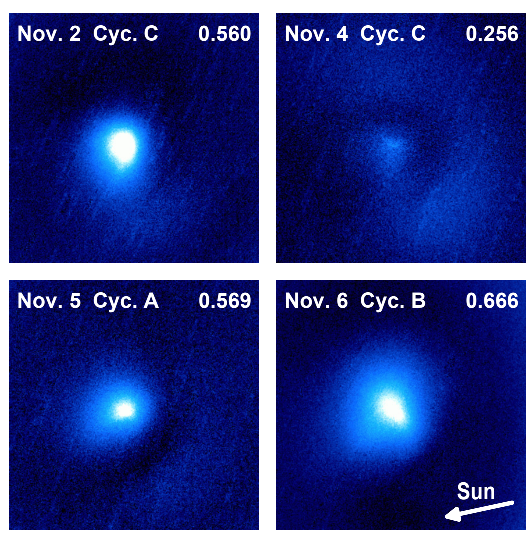

Figure 1: Examples of the residual images for CN. Dates, cycles and rotation phases are displayed. North is up, east is to the left. The field of view is 6.4 arcmin (43.8×10^3 km at the nucleus).

Image processing revealed gas shells, arcs, jets and spirals. These transient structures look very similar for all the observed molecules, when compared at similar moments in time. Hence, it seems that the progenitors of these radicals were emitted from the same regions of the nucleus, which implies homogeneity with respect to their parents, in contrast to the reported heterogeneity for CO_2 and H_2O [1]. Surprisingly, the residual images of the dust coma appear to be almost featureless.

We observed three epochs of increased activity: on November 2 and 5 the central CN shells appeared and brightened while on November 6 they faded. These shells expanded outwards, forming arc- and spiral-like structures which moved across the coma with the projected velocities between 0.1 and 0.3 km s^{-1}. On November 6 we observed a corkscrew pattern, very similar to those reported before [4]. The outer parts of this feature moved with the projected velocities of 0.43±0.02 km s^{-1} in the north-east part and 0.66±0.02 km s^{-1} in the south-west part.

Additional processing of the residual frames revealed that on the three nights the central shells had different profiles and presented different behaviors. It appears consistent with the best repeatability of the coma structures every three precession cycles [1, 2]. Following the nomenclature introduced earlier [2], we enumerate these three consecutive precession cycles as *A*, *B* and *C* with the moment of the *EPOXI* encounter at the middle of *Cycle B*.

We also performed periodicity analysis of the photometric signal measured in a small central part of the coma. The optimal solution yields the period of 18.32 ± 0.30 h, very close to what was found from HCN [2]. Since HCN is considered as a parent molecule of CN, we investigated the correlation between their variabilities and found a good agreement. Comparison of the photometric results obtained for CN, C_3, and C_2 shows that all the three radicals behaved in the same way, presenting very similar amplitudes and phases of the signal variations. This further supports our conclusion of the nucleus homogeneity with respect to the parents of these radicals.

The periodic variation of the CN signal can be attributed to the nucleus precession which periodically exposes the volatile-rich area [1] to the solar light. The suggested roll of the nucleus about the shortest axis of inertia (longest nucleus extend) implies differences in insolation over this area and can possibly activate or deactivate some other vents. Such scenario can easily explain the observed differences between the consecutive precession cycles.

Analysis of the evolution of the corkscrew structure visible on November 6 shows, that it expanded strictly radially, having no curvature typical for arcs and spirals. Hence, we assumed that the direction of expansion of this unique feature indicated the projected direction of the precession axis. After combining this information with the orientation of the active part of the nucleus obtained from *EPOXI* [1], we concluded that the precessional angular momentum vector was directed towards RA=122° and Dec=16° (epoch J2000.0) at the *EPOXI* encounter.

Acknowledgements

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