EPSC Abstracts
Vol. 10, EPSC2015-592, 2015
European Planetary Science Congress 2015

Re-analysis of the Giotto mission data obtained by the Halley Multicolour Camera (HMC) with aim of large particles detection in the inner coma of comet 1P/Halley

O. S. Shalygina, H. U. Keller and J. Blum
Technische Universität Braunschweig, Institute for Geophysics and Extraterrestrial Physics (IGEP), Braunschweig, Germany (o.shalygina@tu-braunschweig.de)

1. Giotto mission and HMC

The Giotto spacecraft (SC) mission was the ESA's first interplanetary mission, that made close-up observations of a comet. The Giotto spaceprobe passed the nucleus of comet Halley at a fly-by distance of only 596 km early on 14 March 1986. During the approach, 2304 images of the comet were taken by the Halley Multicolour Camera (HMC) through different filters.

The HMC experiment was a high-resolution imaging system onboard the spin-stabilized SC. Its spin axis was closely aligned with the SC-comet relative-velocity vector. Pointing of the camera was achieved by the spinning motion of the SC for one dimension and by rotation about an axis perpendicular to the spin of the SC for the other dimension. The spin period was about 4 seconds and the nominal imaging resolution was 22 m at 1000 km distance [1, 2].

HMC was taking images in the so-called Time Delay and Integration mode [2]. In this mode, only a narrow part of the CCD detector was uncovered, and vertical scan-out was provided by the spacecraft (and therefore the camera) spinning. During this spinning charges were transferred line-by-line in the same direction. The slit was made wider than 1 pixel, which increased exposure time but degraded the sharpness to some extent. The portion of the sky swept by the exposed lines during image acquisition was a section of an annulus resulting in over-sampling at the end of the exposed lines nearest the SC spin axis and under-sampling at the other end [2].

Several impacts of dust particles on the spacecraft were detected during the fly-by by the analysis of the changes in the SC attitude and spin period [1]. The changes occurred in large steps, requiring many impacts of massive dust particles well above an effective mass of 10 mg, which implies that a significant part of the cometary dust mass is contained in rather large particles. Moreover, since the time of the Giotto mission, large dust particles have been detected in the inner coma of other comets. The coma of comet 103P/Hartley 2 has a significant population of large particles observed as point sources in images taken by the Deep Impact SC, with particle radii extending up to 20 cm, and perhaps up to 2 m (dependent on the assumed albedo) [3]. So, it is worthwhile re-analyzing the HMC data for large-particles detection at HMC images.

2. Detectability of large particles by HMC

Before searching the particles in the HMC images, it is required to estimate ability of the HMC to detect such particles at all. The minimum detectable particle radii depend on their light scattering properties. Our estimations show that dusty particles with radii of about 1 m to 1.5 m and larger can be detected at the closest approach (in case of high-albedo icy particles, the size decreases to centimeters). These obtained values are in accordance with the estimations made for comet 103P/Hartley 2 [3].

Our estimations show that particles near the nucleus (distance from the camera to particle $\sim 10^3$ km) may be detected even if they are moving quite fast, but for the particles that are ten times closer to the camera (100 km) tangential speed of kilometres per second significantly decreases detection possibility.

If the ejected particle moves directly to the place where the HMC is at the time of observations, it can become more visible for the camera. If a particle moves with a speed of at least $10\,\mathrm{m\,s^{-1}}$, it can easily travel tens of thousand kilometers in three months (approximate time from the start of the nucleus activity to the HMC observations in March 1986).

According to our estimations of particle detectability, a set of images with numbers from 3436 to 3493 (distances from camera to nucleus are in the range of 20 000 km to 4000 km) was selected to search for the evidence of large particles.

3. Searching for the large particles

It is not sufficient to analyse the consecutive images by the image-differencing method. To distinguish between dust particles and sporadic noise in the images, space coherence of the former may be used. Thus, precise boresight vectors are a crucial part of the particle detection method. Positions of moving particles at subsequent times must form straight lines with an origin at the nucleus. What we expect from the algorithm is the confident detection of all pixels that contain probable images of a dust particle, which stays or moves with arbitrary speed along a straight line in space.

Our particle-detection algorithm consists of three main blocks:

- Detection of suspicious pixels (whose brightness significantly differs from that of surrounding pixels) in images.

- Finding all possible trajectories that can produce these pixels.

- Validating the derived trajectories: the valid ones have to start at the nucleus, the velocity of the particle along the trajectory has to stay constant within reasonable limits, and trajectory intersections with the boresight vectors have to be in the correct order.

A detailed description of the particle-detection algorithm, its implementation and optimization, as well as the results from our analysis of HMC images will be presented.

Acknowledgements

This study is supported by European Space Agency grant no. 4000109609/13/NL/JK. We are grateful to the staff of the Max-Planck-Institut für Sonnensystemforschung (Göttingen, Germany), namely to U. Mall, I. Pardowitz and H. Michels, for their help with HMC data conversion, and to J. Kramm and W. Curdt for the consultations and productive discussions.

References

[1] W. Curdt and H. U. Keller. "Large dust particles along the Giotto trajectory". In: *Icarus* 86.1 (1990), pp. 305–313.

[2] H. U. Keller, W. Curdt, et al. *Images of the Nucleus of Comet Halley obtained by the Halley Multicolour Camera (HMC) on board the Giotto spacecraft.* Ed. by R. Reinhard, N. Longdon, et al. Vol. 1. Atlas of Images the Nucleus of Comet Halley. ESTEC, Nordwijk, The Netherlands: ESA Publications Division, 1994.

[3] M. S. Kelley, D. J. Lindler, et al. "A distribution of large particles in the coma of Comet 103P/Hartley 2". In: *Icarus* 222.2 (2013), pp. 634–652.