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TITLE: DUST-GAS INTERACTION DEDUCED FROM HALLEY MULTICOLOUR CAMERA OBSERVATIONS

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Dust-Gas Interaction Deduced from Halley Multicolour Camera Observations

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Abstract

The dust and gas productions of Comet Halley were measured by the dust counter and the mass spectrometers on the Giotto spacecraft. These instruments give only little information about the spatial asymmetry of the activity. The asymmetry in the dust production is clearly evident from the dust jets seen in the Halley Multicolour Camera images. Since the dust is entrained by the gas, production must be similarly asymmetric. We relate the intensity profiles along and across several dust jets to their source regions on the nucleus. Properties of the dust jets are investigated. A few compact, but highly active source regions on the nucleus produce most of the visible dust and can account for most of the gas produced by the comet.

Keywords: Halley Multicolour Camera, Dust and Gas Production, Dust and Gas Source Areas on Nucleus

Visible in the Halley Multicolour Camera (HMC) images are two bright and several fainter, jet-like dust emissions. The brightest of these emissions will be discussed first. Asimuthal profiles indicate that it is about 3 km in diameter near the surface of the nucleus and contains five narrower columated beams that are somewhat stronger than the rest of the feature. The active area, which is the source for this dust emission, is visible on the nucleus between the limb and the morning terminator. It is about 3 km in diameter. At least one of the fine structure beams can be traced to its origin and appears to be about 0.5 km in diameter and lies within the larger active area (see Fig. 5 in Keller et al., 1986). It is tempting to ascribe a somewhat more volatile composition to the source of the fine structure beams relative to the rest of the active region.

The camera can detect only dust, not the gas. Even the finest dust grains will escape detection by the camera. However, all dust must be entrained by escaping gas. If the gas is produced primarily in the active areas, then pressure equalization will cause it to spread over and around the surface of the nucleus. Since the finer dust can be accelerated easily, it will be entrained by this surface breeze. Some of it may settle over inactive regions and possibly cause a change in the albedo. The very loosely settled dust may produce many pores in which light gets trapped more completely than in the old surface when the comet was far from the sun.

The spreading of the dust by surface breezes is consistent with HMC observations which indicate more dust on the right side of the nucleus in the north, nearer to most of the active areas, than in the south. The larger dust grains, that are less influenced by the surface breezes, tend to remain in the jet-like features.

If we assume that the volatile composition of the source of the fine structure beams is 75% water and 25% more volatile material, then the production rate is Z 2×10^{18} molecules $cm^{-2} s^{-1}$ for sun light with normal incidence. Five such areas with 0.25 km radius produce 2×10^{28} molecules s^{-1}. If the rest of the active area is composed of 80% water and 20% more volatile material, its production rate is Z 1.8×10^{18} molecules $cm^{-2} s^{-1}$ for sun light with normal incidence. Excluding the fine structure source areas, the gas production is 1.1×10^{29} molecules s^{-1}, with the fine structure areas it is 1.3×10^{29} molecules s^{-1}. Since the sun is on the left, 17^{o} behind the plane of the image, the angle of incidence is about 30^{o} and the gas production from the source area of the brightest jet-like feature is about 1.1×10^{29} molecules s^{-1}.

The second brightest jet-like feature on the HMC images has similar dimensions but its source is on the back of the image plane (see Fig. 4, Keller et al., 1986). The angle of incidence of sun light is less than 30^{o}. The gas production in the two brightest jet-like features towards the left in the HMC images is about 2.3×10^{29} molecules s^{-1}.

As seen from larger distances (~124,000km), the inner dust coma has a distinct extension in the southerly direction in the approximate ratio of 1.6:1 relative to the solar direction (see Fig. 1 in Keller et al., 1986). If the extent of the dust coma on the afternoon side of the comet - moving away from the Giotto spacecraft in a southerly direction - is a measure of the source strength, then jet-like features, or a fan-like feature, responsible for it must produce at least $1.6 \times 2.3 \times 10^{29}$ molecules s^{-1}. For comparison, the gas production rate measured by the neutral mass spectrometer (Krankowsky et al., 1986) is 6.9×10^{29} molecules s^{-1}.

Our conclusions are:

1. The primary source for gas production is in the active areas that also produce the jet-like dust features.

2. Most of the surface area (~80% of the sunlit surface) is

relatively inactive.

3. Pressure equalization of gas issued in jet-like dust features causes surface breezes.

4. Surface breezes spread fine dust over the nucleus, thereby possibly changing its albedo.

5. Larger dust particles tend to remain in the jet-like features, scattering light in the visible part of the solar spectrum.

6. Small jet-like dust features are present and add to the gas production.

7. Very weak outgassing from the "inactive" surface area cannot be ruled out.

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