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A POSSIBLE EXPLANATION FOR THE INCONSISTENCY BETWEEN THE GIOTTO GRAIN MASS DISTRIBUTION AND GROUND-BASED OBSERVATIONS

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The Problem:

Giotto measured the *in situ* Halley dust grain mass distribution with two instruments, PIA (Particle Impact Analyzer) and DIDSY (Dust Impact Detection System), as well as the total intercepted mass from the deceleration of the spacecraft (Giotto Radio-Science Experiment, GRE). The mass distribution for $m < 10^{-10}$ kg is dealt with elsewhere (McDonnell *et al.*, 1987, *Astron.& Astrophys.*, in press) and was measured by the Vega spacecraft with similar results. DIDSY was, however, the only experiment to measure individual grain masses for $m > 10^{-9}$ kg. This "discrete" data was transmitted for an unbiased sample of grains large enough to excite more than one sensor on the front shield. Preliminary analysis of these discrete data (McDonnell *et al.*, 1987) indicated a mass distribution index $\alpha' \cong 0.5$ (where $N (> m) = K{\cdot}m^{-\alpha}$), significantly lower than for the lower mass grains. A consequence of this low slope is that the contribution to the total cross-sectional area of grains (upon which ground-based observations of scattered and thermal radiation depend), and the total grain mass, is dominated by these large grains.

Ground-based observations made shortly before encounter (Hanner *et al.*, 1987, *Astron. & Astrophys.*, in press) (Hayward *et al.*, 1987, *Nature*, **326**, 55-57 and this report) have fluxes much higher than would be predicted from Giotto data. In addition, the observed silicate emission around 10μm cannot be fitted with models based on the Giotto mass distribution, due to suppression of the feature by the dominant large-mass grains (Crifo 1987, ESA SP-278, in press). Thus some explanation must be found for the discrepancy between the Giotto mass distribution and ground-based observations.

The Solution:

Interpretation of DIDSY data depends on the momentum transfer to the front shield, rather than the momentum actually possessed by the grains. For impacts which do not penetrate the shield, the momentum transfer is greater than that carried by the particle itself, since shield material is also vaporized and ejected. As the penetration mass is reached ($\cong 3\text{x}10^{-9}$ kg), this enhancement must be derated to allow for ejecta continuing through the rear of the 1 mm shield. Figure 1 shows the DIDSY discrete data for a realistic range of values for this derating factor (γ). Two points in particular should be noted:

1) The region of overlap with the binned data at $\cong 5\text{x}10^{-10}$ kg shows the same mass distribution index $\cong 0.9$.

2) For <u>any</u> reasonable value of γ the large-mass slope is shallower up to the limit of data ($\cong 10^{-6}$ kg) and lies in the range $0.3 \leq \alpha' \leq 0.6$.

The GRE total spacecraft deceleration is a measure of the <u>average</u> mass distribution up to the largest impacting particle. The average large grain mass index which satisfies both the DIDSY data and GRE total mass is $\alpha' = 0.54 \pm 0.02$ up to $m \cong 5\text{x}10^{-4}$ kg. (This assumes a r^{-2} cometocentric density distribution for the time near closest approach when telemetry was lost.) This is only an average value; if the slope is shallower (say

$\alpha' \cong 0.4$) for $10^{-9} < m < 10^{-6}$ kg, then it would be steeper ($\alpha' = 0.85$) above 10^{-6} kg to satisfy the GRE total mass. Herein lies a possible explanation for the inconsistency between observations and spacecraft data.

Giotto encounter lasted only a few minutes, but grains which were encountered took between one and six or more hours to arrive from the nucleus, with the largest mass grains having the lowest velocities (e.g., Gombosi, 1986, ESA-SP-250, Vol. II, 167-172). Thus, if the level of activity from the region of the nucleus surface that was sampled changed during this period, the observed mass distribution would not be representative of that near the nucleus. Figure 2 shows the mass distribution that would be observed for a model with high activity six hours before encounter, falling by a factor of 30 one hour before. This model satisfies both the observed DIDSY and GRE data and the ground-based observations, since the latter, made $\cong$ 6 hours pre-encounter, would sample the small grains emitted from the high activity region.

Conclusions:

1) Giotto DIDSY and GRE data represent observations of dust originating from a narrow track along the nucleus. They are consistent with ground-based data (which measure the average coma properties), if assumptions are made about the level of activity along this track.

2) The actual size distribution that should be used for modeling of the whole coma should not include the large mass excess actually observed by Giotto. Extrapolation of the small grain data ($\alpha \cong 0.9$) should be used, since for these grains the velocity dispersion is low and temporal changes at the nucleus would not affect the shape of the mass distribution.

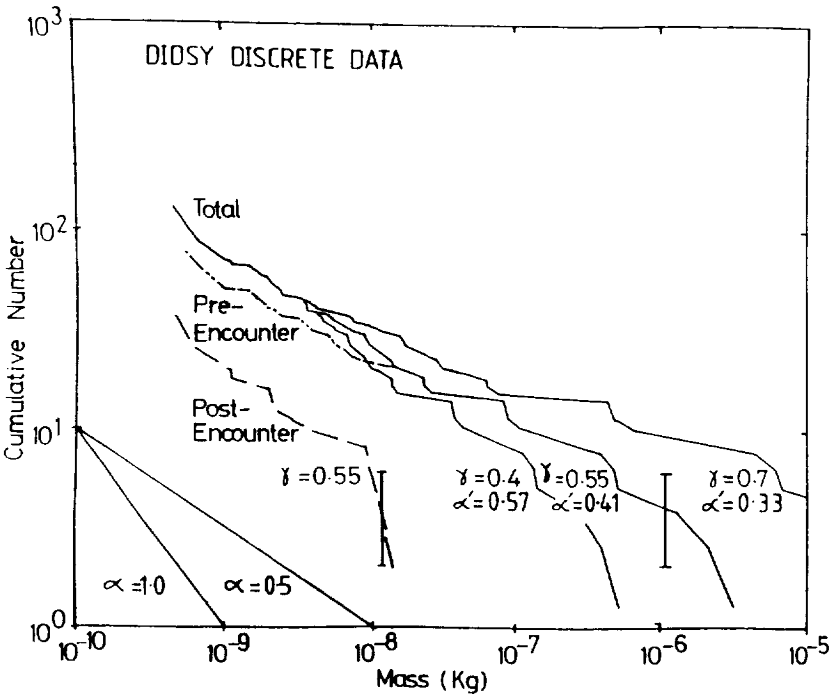

Figure 1. Relative fluence for DIDSY discrete data. The performation limit of the front shield is taken as 3×10^{-9}kg. The different curves correspond to different values of the momentum derating exponent (see text).

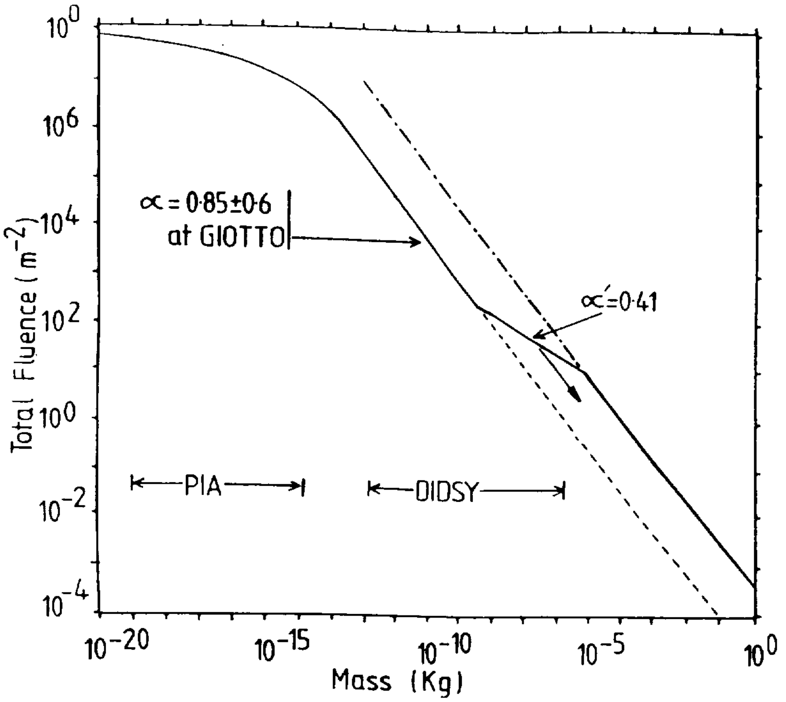

Figure 2. A fluence plot (solid line) which satisfies the Giotto data and represents an intermediate stage between an outburst (chain line) and an inactive period some time later (dotted line). The arrow shows how the distribution would change with time. In addition α' would increase with time. See test for details.