CALIBRATION OF THE GALILEO/ISPM DUST DETECTORS WITH IRON PARTICLES

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ABSTRACT. The impact-ionization-detectors for the Galileo-/ISPM-Missions were calibrated using about 7000 iron particles with speeds between 1 km/s and 67 km/s and masses between 10^{-15} g and 2 x 10^{-10} g. These calibrations showed that the impact charge (Q) was proportional to the particle mass (m) at a fixed velocity. The speed dependent charge yield (Q/m) showed significant deviations (up to one magnitude) from a power law.

There are three independent methods (risetimes of electron and ion pulses, amplitude ratio between channeltron and ion pulse) for measuring particle speed and two possibilities (charge yields of electron and ion pulses) for mass measurement. This calibration showed that the speed can be determined within a factor of 1.2 and the mass within a factor of 2.0.

1. SCIENTIFIC OBJECTIVES

The Galileo dust detector shall measure the distribution and the dynamical properties (speed, mass, flight direction) of micrometeorites in Jupiter's vicinity, especially their interaction with the Jovian natural satellites and its magnetosphere.

The ISPM dust detector will determine the three-dimensional distribution of the zodiacal cloud and offer means to distinguish between the different models of its shape.

Both missions are able to do measurements in the asteroid belt and to detect dust of cometary origin.

2. THE SENSOR

The sensor is an impact-ionization-detector based on the HEOS 2-detector (Hoffmann et al., 1975). Its main improvements are:

- the increase of the target area (1000 cm², which is about 10 times the area of HEOS 2)
- the use of entrance grids to measure the electrical charge of a dust

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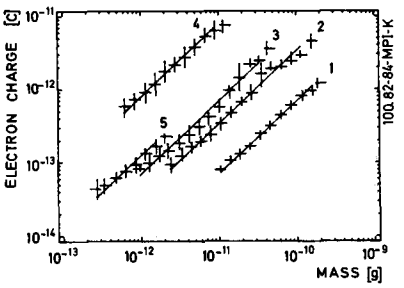
particle entering the sensor
- the introduction of a channeltron, which measures part of the impact-ions. This helps to identify reliably impacts and to determine the speed of a particle.

The measured quantities are
- the amplitudes of ion, electron and channeltron pulses
- the risetimes of ion and electron pulses
- the primary charge of a particle.

3. CALIBRATION AND RESULTS

The calibrations were done at the Heidelberg dust accelerator using about 7000 iron particles with speeds between 1 km/s and 67 km/s and masses between 10^{-15} g and 2 x 10^{-10} g. Even at high velocities (> 20 km/s) enough particles were obtained to get good statistics for the data evaluation. Four units (both flight units, the Galileo flight spare unit and the ISPM engineering model) were calibrated.

It was found that for fixed velocities the impact charge was proportional to the particle mass, as shown in Figure 1 for 5 different speeds.



Speed ranges:
1: 2.2 - 2.5 km/s
2: 3.8 - 4.3 km/s
3: 5.8 - 6.3 km/s
4: 7.8 - 8.5 km/s
5: 10.0 - 11.0 km/s

Figure 1. Electron charge versus particle mass. For optical reasons curve 4 shows the charge multiplied by 10. The plotted lines show proportionality.

Therefore the charge yield (impact charge/particle mass, Q/m) could be plotted as a function of velocity (Figure 2). The differences in yield between the units are smaller than the deviations of the curves. So all the measurements could be combined.

In earlier experiments (Hoffmann et al., 1975, Grün, 1981) the charge yield was found to be a power law of the velocity. This is not the case for the Galileo/ISPM detectors. The charge yield shows a deficiency up to one magnitude in the region between 4 km/s and 20 km/s.

This may be caused by energy dissipation in melting processes of target and/or projectile. Studies of Eichhorn (1976) on the impact flash showed similar deviations, depending on the materials.

In addition there is a geometrical factor. The DIDSY-detector (Grün, 1984) shows similar but not as strong deviations. It has a mainly plane target, in contrast to the curved configuration of the

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Galileo/ISPM detector.

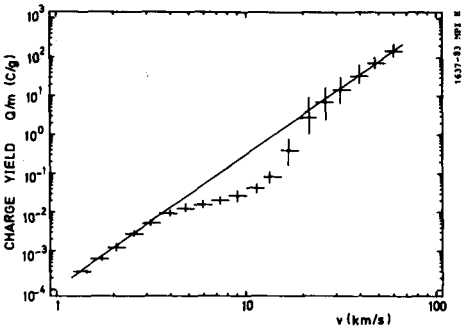

Figure 2. Charge yield Q/m (ions) plotted against velocity. In the region between 4 km/s and 20 km/s Q/m shows a deviation from a power law, fitted at low and high velocities.

The speed of a particle can be determined by three methods: the rise-times of electron and ion pulses and the amplitude ratio of channeltron and ion signals. The accuracy (1 σ) for each method is a factor of about 1.7. Using all the three possibilities the deviation is a factor of 1.2.

The particle mass can be determined from the speed (calculated as above) and the charge yields of impact ions and electrons. For one possibility the accuracy factor is $\sim$2.2, using both $\sim$2.0.

These factors are of course only valid for iron particles. Calibrations of earlier detectors showed that the calibration curves also hold for other projectile materials, but with somewhat reduced accuracy.

The overall accuracy of the speed and mass determination with the Galileo/ISPM detectors will be better than that of the Helios experiment which was characterized by factors 2 and 10, respectively.

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