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The measurement of micron sized impact fragment using delay line detector

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Abstract

ATHENA is a successor of the X-ray mission XMM-Newton telescope. A special issue for the ATHENA telescope is the possible scattering of micron sized particles through the mirror shells, which might damage on the CCD optical system. The generation of scattering fragment particles upon hypervelocity impact under an oblique angle is of central interest for this project. The ejecta generation is characterized by the distributions of size, mass, velocity and ejection angles. In this study, we employ MCP detector with delay line anode to monitor impact ejecta.

1. Introduction

Experiments showed that the number of secondary impacts from oblique impact angles is more than two orders of magnitude higher than from primary impacts [1]. In the past, two detection methods were used to measure micron sized impact ejecta grains depending on the size of the impacting particles: Particles with diameters larger than 10 μm were accelerated in plasma drag- and light gas gun accelerators to speed between several hundred m/s and about 3 m/s. The ejecta generation was studied for impacts of glass spheres onto ice targets in dependence on the target temperature and the impact angle. A setup of thin films was used to record the size distribution and the ejection angle of the secondary particles [2]. The flight time and subsequently the speed of the secondary particles was measured with piezo detectors. The detection method for smaller and faster dust particles (μm and sub-μm) uses the light flash generated by impacting secondary particles onto the entrance window of a photomultiplier (PMT) [3] .

In this study, we employ MCP detector with delay line anode to monitor impact ejecta. The ejecta speed can be determined from the flight time between the primary impact and the impacts of the ejecta on MCP. Studies investigating the glow of the primary impact showed a direct relation between the MCP amplitude and the particle mass and the impact velocity. This allows to use the results of the intensity measurement for the estimation of the particle mass and size. The MCP detector with delay line anode is high resolution 2D imaging and timing device for fragment particle at high rates with limited multi-hit capability.

2 Experimental set up

The 20 kV dust accelerator located at Institute of Space systems (IRS), University of Stuttgart, is used in order to obtain experimental results of the delay line detector system. The detection systems for secondary ejecta particles resulting from the interaction between the dust particle and the mirror surface are placed behind the mirror. The target mirror disk is placed behind the tube detector (see Figure 1). The mirror could be tilted with respect to the direction of the incident dust particle to enable different grazing incidence angles with angular resolution better than 0.02 degrees. The setup offers the option to move the mirror laterally out of the particle path so that the effect of the direct dust particle impingement could be tested. Both the tube and the top electrode were connected with charge sensitive amplifier for signal detection. There is also a positive bias voltage added above the mirror target to collect the electrons generated by primary impact. In order to avoid the influence on the trajectory of tiny ejecta particles with surface charge, the voltage is only selected as +100 V. We can check if the particle passed through the tube and touched the mirror. The individual particle charge and speed parameters are obtained by the tube detector, and the mass of the particle can be calculated.

3. Primary experimental results

Micron sized iron (ρ = 7.8 g/cm^3) particles are used to test the experimental set up, and platinum coated ortho-pyroxene to (ρ = 3.4 g/cm^3) particles are used

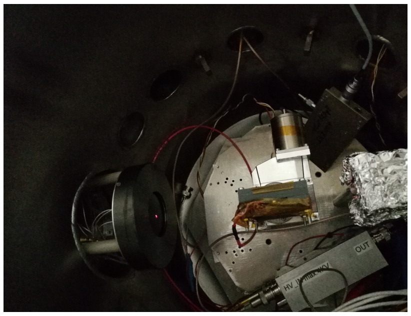

Figure 1: Experimental set up in vacuum chamber at 20 KV dust accelerator.

to simulate the mineral dust grains in the interplanetary space. The delay line detector system can be used measure micron and submicron sized dust grains with the speeds of between 100 m/s and 6 km/s. Figure 2 shows the calibration results of iron particles. The gain of MCP is adjusted by two different voltages (1800 V and 1950 V). The amplitude obtained by the MCP is similar with impact ionization charge:

$$A = \alpha \times m \times v^{\beta} \tag{1}$$

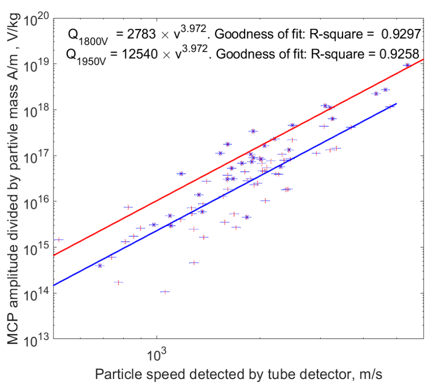

Figure 2: Calibration of MCP amplitude to mass ratio and dust particle speed.

The typical signal for an impact fragment group is shown in Figure 3 . Each peak is related to a single fragment impact. The analysis showed that the speeds of impact fragments are lower than the incident dust projectile.

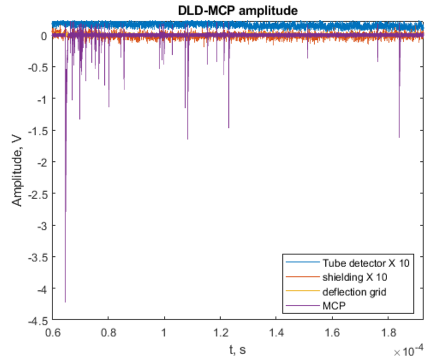

Figure 3: Calibration of MCP amplitude and dust particle parameters.

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