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Progress in Dust Acceleration Techniques

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Abstract

The Heidelberg dust accelerator, a 2 MV electrostatic accelerator, equipped with a dust particle source, provides micrometer-sized particles as projectiles for hypervelocity impact experiments [1]. Recently there has been some significant progress regarding materials that can be used for acceleration as well as concerning the detection, monitoring, and selection of the particles.

1. Introduction

In the past five decades various dust detection instruments on spacecrafts have been used successfully to investigate *in situ* the physical, dynamical, and chemical properties of cosmic dust in the Solar System. These instruments use the fact of the particle impinging onto a target and the physical processes which origin from this event. This can be for example the emerging of an impact ionisation plasma from a metal plane target or the track of the particle in an aerogel. To calibrate an instrument and to get an deeper understanding of the involved processes, one has to make measurements under similar and well defined conditions. For this purpose particles are charged, passed into an accelerating field, and focused onto the investigating instrument.

2. New dust materials

For the above described method of acceleration to work, the particles must therefore be capable of carrying charge and hence the range of materials used has been restricted to those which are either wholly conductive or those with a conductive coating. In the last few years two techniques of coating underwent significant improvements:

- Coating of organic and silicate materials with conducting polymers (PPY-coated) [2]
- Coating of silicate particles with platinum [3]

This opens up a whole new range of material types to investigate. Table 1 shows a selection of materials used in the Heidelberg dust science lab.

Table 1: List of coated and successfully accelerated materials

Coating Method	Accelerated Material
Pt - coated	orthoPyroxene Anortite mono-disperse SiO_2 Pyrrhotite FeS
PPY - coated	Latex Olivine Pyrrhotite

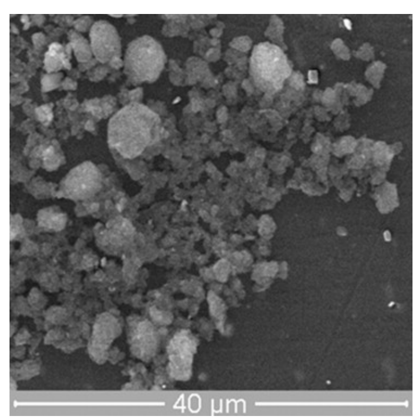

Figure 1: An SEM image of the Pt-coated silica particles [3].

3. Improvement of the Particle Selection Process

3.1 Charge sensitivity of the beam line detectors

After their acceleration the particles can be selected due to their velocity, charge, and mass according to the requirements of the specific experiment. For this the particles are been detected by a chain of detectors measuring the particle's primary surface charge using an induction tube and a charge-sensitive amplifier (CSA). Due to a rising interest in measuring particles with very low primary charges a new low-noise detector has been developed for the beam-line of the Heidelberg dust accelerator as shown in Fig. 2 [4].

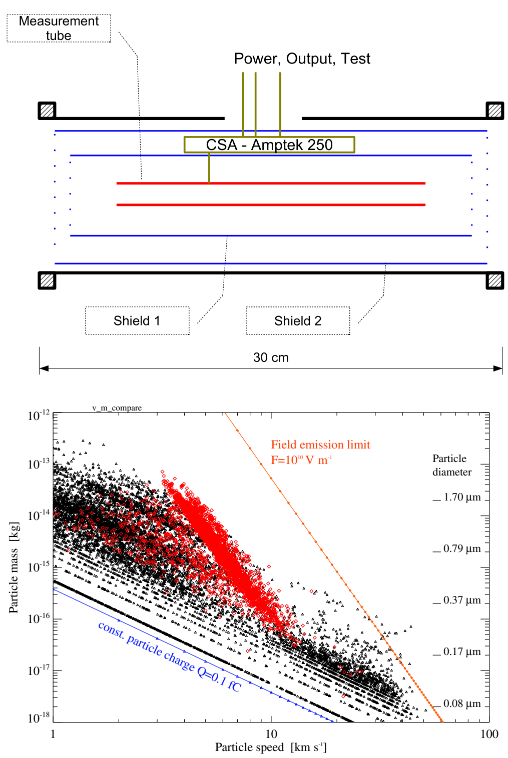

Figure 2: **Above:** Charge detector developed with multiple electrical shields for the reduction of noise and thus, lowering the threshold for particle detection. **Bottom:** Dust particle properties determined by the particle selection unit with the previous detector (red symbols) and the new beam detectors (black symbols) of the dust accelerator. The new detector monitors much smaller grains. The blue line at the bottom determines the detection threshold of 0.1 fC and indicates particles with a constant charge [4].

3.2 Selection of particles due to their speed, charge, and mass

The main component of the new particle selection unit (PSU) is a Field Programmable Gate Array (FPGA), capable of real time monitoring the particle's speed and charge. The selection of particles due to charge, speed and / or mass is possible.

3.3 Platform independent software architecture

The hardware consists of the FPGA and an embedded system running a hardened Linux variant hooked to an ethernet network. On the Linux system, a small web server delivers the web client interface code to the PSU client computer. This client system can be placed anywhere, as long as there is connectivity to the institutional network. The PSU client runs on a web browser, and through an AJAX architecture (Asynchronous Javascript and XML) the data is sent from the PSU server. By this setup, the computing and network load on the PSU server is minimised. Only the actual measurement event values are transferred for an event. All data visualisation is done locally on the client system.

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