High–velocity impact experiments on meter–sized targets

Jean-Marc Petit <petit@obs-nice.fr>
Patrick Michel <michel@obs-nice.fr>
CNRS, Observatoire de la Côte d'Azur, BP 4229
06304 Nice Cedex 04, France

Partners

The following partners have already shown interest in this project: Centre d'Essai des Landes (CEL), Centre Technique d'Arcueil (CTA), Pr. Willy Benz (Berne University, Switzerland), Dr. Mario Di Martino (Torino Observatory, Italy).

Proposed experiments

We plan to perform experiments of high–velocity impacts on meter–sized solid targets. The range of projectile velocities we are interested in goes from several hundreds m/s to several km/s. The main objective of these experiments is to improve our knowledge of a wide variety of phenomena occuring during collisions: fragmentation modes, the size and shape of the fragments, their rotational and ejection velocity fields, the fraction of impact energy transfered into fragment kinetic energy. Up to now laboratory experiments have been performed on targets at most 20 centimeters in size. It has been realized that it is impossible to simply extrapolate the outcome characteristics of the collisions to larger target size. The proposed new experiments will help to constrain the available models, and will allow for the first time to measure physical quantities (pressure, displacement, temperature, ...) during the fragmentation process, thus improving our knowledge of the physical processes at work. They will also lead to industrial developments.

Scientific Rationale

The role of collisions is fundamental in different astrophysical fields such as the origin of our Solar System and the formation of planets, the evolution of small bodies in the Solar System, and even in the fate of the human kind, since a collision of a dangerous asteroid on the Earth is a threat that cannot be neglected.

To build a coherent model of collisional and dynamical evolution of our Solar System, and to be able to face the potential threat of an asteroid coming to the Earth, a good knowledge of the collisional process and of the outcome characteristics as a function of the impact conditions is required.

Experimental strategy

Our project is thus to perform high–velocity impact experiments using targets in the size range $1 - 1.5$ meters in radius. These experiments will be done in relation with a tridimensional hydrocode developed by our collaborator Pr. Willy Benz, using the concept of Smooth Particle Hydrodynamics (SPH), in order to represent the evolution of stress and strains inside the material and important physical quantities such as the internal energy of the target and crack propagation.

Besides the increase by an order of magnitude of the size of the target, the great novelty of these experiments, compared to previous ones, will be the possibility of measuring physical quantities during fragmentation. Simulations with our SPH code will allow first to guide the choice of the experimental parameters and to estimate the order of magnitudes of these physical quantities. In turn, the experimental results will allow to calibrate the free parameters of the numerical models.

Our first experiments will consist in 6 impacts, 3 at 400 m/s and 3 at 800 m/s, with a projectile mass between about 10 and 100 kg. This allows to investigate different impact conditions. The projectile will be accelerated on the 2 km railway available at the CEL. The target will consist in a sphere of radius as large as 1.5 meter. Both target and projectile should be made out of concrete.

Industrial developments

The industrial developments will basically concern three distinct fields: the knowledge of the material behavior, the development of measuring instrumentation, imaging and pattern–recognition technics.

First, the experiments will provide precious information on the behavior of the used material during energetic impacts. The results should strongly interest industries who could then find a motivation to build and provide the targets. These data will bring an important contribution to the study of the protection of sensitive infrastructures.

One of the innovative aspects of the proposed experiments is the possibility to place several captors on and around the target, allowing to measure different physical quantities under unusual conditions during the impact and along the fragmentation phase. This will lead to developments of captors with fast response time (microsecond to millisecond) and high dynamical range.

The effects of the impacts will be filmed by four fast cameras. The images will be digitalized, and each individual fragment will have to be automatically detected and identified. The problems of pattern–recognition, of the determination of topography, and of the following of objects during their motion are *hot topics* in the imaging research field. It will require the writing of new softwares which could then be applied to the study of automatic control of autonomous mobile engines.

The results of these experiments will be published in specialized journals. Industrial ownership of data or technics will however be preserved. The experiments are available to be used for advertisement by our partners as they see fit.

Estimated total budget: $\sim$ 1.7 M Euros ($\sim$ 11 MFrs).