Education

Fly your Thesis! 2010

Scientific Proposal

Team composition:

Team's Number: 1207

Team's Name: supermassive B.

Experiment Title: Deep Impact !

Endorsing Professor:
Title, Name: Astronomist, Augereau
University: University Jospeh Fourrier

Team Members:

1. *Name:* Audrey Grockowiack
   University: université Juoseph Fourrier
   Level of Study (Master or PhD): Ph.D. (1st Year)

2. *Name:* Magalie Dugué
   University: Université joseph Fourrier
   Level of Study (Master or PhD): Ph.D. (1st Year)

3. *Name:* Rémi De Guiran
   University: Université Joseph Fourrier
   Level of Study (Master or PhD): Ph.D. (1st Year)

4. *Name:* Laurianne Palin
   University: Paul Sabatier
   Level of Study (Master or PhD): Ph.D. (1st Year)

One team can include 2 to 4 members.

Abstract:

Please summarise the project described here below and outline the scientific objectives.
Max 20 lines of text.

Collisions between asteroids in a late debris disc have not been explored much yet. Some experiments regarding young discs with gas were carried out. The aim of these experiments was to explore the craterisation phenomenon. In this case, the dust production obtained corresponded to the ejection of the surface regolith by the collision between big bodies with tiny ones.

The aim of our experiment is to study the dust resulting from the collision between an impactor and a target. What we are interested in is the production rate, the size distribution as well as the velocity field of the dust produced.

What we propose to do is to probe a range of collision velocities and impact parameters as well as different chemical types and shapes of samples. This will enable to refine actual simulation of collisions which do not take into account the asteroids composition and the impact parameters in cratering.

All these data collected will probably permit to refine actual models of collisions that doesn't take care (for exemple) of the composition of the asteroids for the dust creation in cratering. An analysis of the dust and the database could even be interesting for the micrometeorit studies and their effect on the bigger asteroids.

Scientific background and objective(s) of the project

What are the scientific objective(s) of your experiment?

Max 3 pages including figures and references.
Please use the standard Arial font in size 10pt.

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Is any research currently going on with respect to the topic addressed? To what extent does this project use results obtained in the past? What is the state of the research activities in that field?

Max 15 lines including references.

The topic we propose to explore is at the heart of the current research lead in the debris disc field since the evolution of a disc can be characterized by the evolution of the dust creation and repartition (A completer). The research endeavours are directed on all scientific aspects : theoretical, experimental and numerical simulations. On the numerical side we can quote non exhaustively an English team from Cambridge University, mainly lead by Sarah T. Stewart, which performs numerical simulations of different types of collisions to address different issues such as the collisions of at high velocity of planetary embryos in the planetary formation, or the collision of small icy bodies that we can find in the Kuiper belt.

- Stewart, Leinhardt: ApJ 691 (2009), 133
- Stewart, Leinhardt: ApJ 691 (2009), 133

From the experimental point of view, the German duet of Blum and Wurm have been particularly active for the last 15 years in the study of interplanetary dust. They developed investigation systems that were tested in parabolic flights and on board the Discovery Space Shuttle, and they also performed experiments with the Bremen Drop Tower.

- Blum, Wurm: Annual Rev. Astron. Astroph. 46 (2008), 21 (+ REF BLUM WURM)

+ efforts theoriques actuels

Why do you need to perform your experiment in microgravity?

Max 10 lines of text.

The main purpose of the experiment being the analysis of the dynamics of the dust produced by the collision of an impactor and a target in astrophysical realistic conditions, the microgravity aspect is absolutely crucial. Similar experiments have already been performed on ground (REFERENCE) and the main problem encountered was that the gravity obviously caused the dust to crash on the sample or on the bottom of the experiment chamber, therefore not allowing observing its dynamics after its creation.

Another interesting consequence of microgravity that we would like to exploit is the possibility to make of the target and the impactor an isolated system, which would allow us to control through the impactor energy the energy flux going in that system. This would not be possible if we studied a target fixed to a holder because according to its mechanical properties, this holder could absorb a non-measurable part of the incoming energy.

Why would parabolic flights be particularly relevant? Have you used or thought about using other gravity related research systems (neutral buoyancy, clinostats, magnetic levitation, centrifuge, drop tower, sounding rocket)?

Max 10 lines of text.

The neutral buoyancy and the centrifuge are not relevant since the former deals with liquids, and the latter creates hypergravity.

The magnetic levitation is not performing enough for us since we believe it is still quite limited and can only annihilate gravity on drop-like samples. Furthermore, dust created have to be in zero-G too: it's impossible to have a so big volume in zero-G by this method.

The clinostats and the sounding rocket would also be interesting to use but the time scale on which the microgravity is maintained is too long for us.

The drop tower would be interesting to use since it creates good microgravity conditions, but the drop tower campaign doesn't allow as many repetitions of microgravity as the parabolic flights. Furthermore, the timescale of these kind of experiment is insufficient to shock the probe and obtain the field speed of the dust.

A rocket is not relevant for some reasons: First, few minutes is too long and will not permit to have more informations on the dust dynamic created. Second, it would be impossible to make lots of experiments to test different probes and finally it would be too much complicate to automatise completely the experiment.

Since we want to perform our study in microgravity on large, solid samples that we want to change quite often and study the effects on rather a short timescale, we think that parabolic flights would be the perfect research system to realise our study. The large amount of parabolas performed would also be ideal to probe all the parameters and to get a good statistic.

What is the timescale of the phenomena studied in your experiment project and how does that comply with parabolic flights time constraints?

Max 10 lines of text.

We want to study the dust production rate, its size distribution and its dynamics after the impact. However, we are not interested in the long term dynamics of the dust, which can result in the aggregation.

Since we want to study the size distribution of the dust after the impact, we want to avoid this aggregation phenomenon.

It is interesting to note that the timescale will depend of the energy of the shock (the speed of the impactor), and of the size/mass of the dust: bigger dust grains are, slower they will be. For an energetic shock that create a fine powder, few seconds would be enought. But, for a slower shock that create bigger agregate, 10 to 20 seconds are not too much.

Therefore, 20 seconds of microgravity would leave us enough time to shoot the samples and record with a high frequency camera the motion of the dust without creating aggregates. Hence parabolic flights time constraints do fit perfectly with our timescale constraints.

How does the cycle of various g-levels (1g – 2g – 0g) impact your study?

Max 10 lines of text.

We design our experimental protocol to fit the g-levels cycles.

The 0g phase will obviously be dedicated to rule the experiment: one impactor is sent on a sample at a well defined speed and impact parameter. the high speed cameras will film the shock and the dust dispersion during the 10 to 20 seconds of the phasis.

During the 2g phasis, the dust will fall and paste on a especially prepared cartridge of carbon scotch. The sample fall on a net used as dust discriminator, shock absorber for sample and gutter to permit the recuperation of the sample. So, this phasis is essential to clean up the chamber for the next experiment:

The 1g phasis will serve for the preparation of the next experiment: the cartridge is replaced by the cartridge charger and conserved for a electronic microscop analysis. The shocked probe is pushed out with the net and replaced: a mechanic arm take the next sample and put it on the "blocking sample dispositive". And a new impactor is placed in the "gun", the speed and the impact parameter are setted.

Now, the experiment is normally ready for an other cycle.

Experimental procedure

How you are going to fulfil the scientific goal?

Max 15 lines of text.

The scientific goals are to study the velocity field in the dust created by a shock in the regolith as well as its size and mass distribution. It will hightly improve statistical simulations of debris disc since it can permit to have well defined constrain on the cratering effect wich is responsible of a big part of the dust creation process.

It is important to improve these simulations of this process since it is a fundamental tool that is used to know how many materials (planet, asteroid belt, etc...) are present around stars because the presence of matter is deduced from the emission of the dust.

In order to fulfil these goals, we will place our target in a vacuum chamber and will shoot on it an impactor. We will process with two different tool that can be merged to know if results are consitant between them.

First, we will use high frequency camera that will record the dust movement . The analysis of the films with appropriate sofwares developed for fluid mechanics research for example will provide us with its velocity field.

Second, we also want to use a carbon cartridge, placed at the bottom of the chamber, which will work as tape to trap during the 2g phase the dust released. The analysis of each parabola's cartridge will enable us to make statistics on the size and mass repartition of the dust, as well as its creation rate.

A combined study of the trajectories observed on the films and the dust repartition will enable us to check if our experiment is self-consistent.

Which data do you want to measure and how do you want to take measurements?

Max 10 lines of text.

We need two kind of datas: numerical datas corresponding with videos of the impacts to obtain velocity field and physical data corresponded to dust recolted after the experiment to have.

To obtain video and reconstruct the 3D cinematic of the dust and the probe, we need (at least) two hight speed cameras (1500pictures/second) to make stereoscopy. We will use softwares such as imagej or matlab to analyse the film and get the velocity field.

The second kind of data cinsist in stydying dust to obtain mass and size distribution of the dust. To collect it during the 2g phase on a layer of special carbon tape that will be placed at the bottom of the chamber. It will need much more work since it consist in watching the recuperated dust with electronic microscope. It could take several month of analysis.

How many experimenters are needed for your project?
Can you describe the methodology used?

Max 10 lines of text.

For this experiment, we need at least 3 person during the flight.

One person will be responsible for the data acquisition: she will check cameras and luminosity to have the best acquisition possibles. This person may make a pre-treatment on data.

One other person will take care of all the delicate mechanism to see if it work right. And will set the different parameter like the impact parameter and the speed of the impactor.

If there is a problem during one experiment, an other person is necessary since 2 or 3 person will not be too much (furthermore if someone is sick) to repair the experiment fast. To benefit of all paraboles.

What is the expected outcome of your experiment?
Do you expect sufficient measurements to draw statistically valid conclusions?

Max 10 lines of text.

We expect from our mass and size distribution analysis to get a better approximation of the dust creation ratio, which will lead to a better approximation of the amount of material present around stars (since we can only see the IR reemitted or scattered by the dust). It will have a significant impact on modelisation of stellar systems that will be better constrainded.

We also expect from our film analysis to get consistent dust velocity fields depending on the collision initial conditions (such as the sample type and structure, and the impactor velocity and impact angle).

The data collected will permit to upgrade current collisional models and numerical simulations for asteroid belts and will give a better understanding of the cratering process, for a given range of initial parameters never probed before.

Finally, if there is significant differences between dusts produced by our different probes, we can even try to have a trustable idea of the chemical composition of exodust around observed stars.

Experimental set-up

Describe and outline the preliminary set-up of your experiment.

Max 20 lines including drawings.

The experiment will be done in a vaccum chamber. Magali Dugué should be able to obtain light and resistant materials to construct this chamber since her lab, SIMAP, is hightly interrested in collaborating on the materials needed to construct the experiment.

The vaccum will be maintained with a simple vaccum pump. The vacuum needed is not necesseraly of a very hight quality but need to be good enougth in order to be confident with the speed field deduced from movies.

We will creates samples of rock (10 to 20cm) that will be used as a target by compacting powder of terrestrial rocks. This process of fabrication will permit to modelise better the response of the regolith after a shock. The Planetology lab of grenoble is very interrested in collaborating to create these samples.

These samples will be put in a sample charger and picked out by a mechanic arm to be put down on the "blocking structure" that permit to set precisely the position of the sample (precision of the impact parameter).

When zéro-G is attempt, the blocking structure is retracted and then we shoot the sample with a smaller object (1cm) testing different velocities and impact parameters to see their influence on dust production and dynammic.

An ultra-speed camera will study the dynamics of the rocks and of the dust produced. The laog can collaborate actively to furnish a revolutionar ultra-speed camera.

We will ingeneer a system to get back the dust, based on carbon scotch that will permit to analyse it after with an electronic microscop to obtain the composition and shape of the dust grains produced.

After each shock, an automatic system will change the carbon scotch cartridge.

We will also measure the weigh of total mass dust extracted by the impactor.

Is there any safety issue involved in your proposed study? If so please address it and identify the way you handle the issue. (Please, refer to the "INTRODUCTION NOTE TO ESA "FLY YOUR THESIS!" PROGRAM")

Max 10 lines of text.

The vacuum and the shocks of the projectile against the walls of the chamber could be dangerous but we already know some materials that can resist to shocks and vacuum and we will do some test to use the best one.

Academic

What are the benefits of this project for each team member's Master/PhD thesis or University project? Which experimental results does he expect to include in is thesis/project?

Max 10 lines of text.