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MATISSE web-tool functions integration into VESPA-Europlanet 2020 infrastructure: real-time computation and visualization of aerodynamic coefficients for convex objects moving in a rarefied gas field

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Abstract

The large amount of planetary data acquired by planetary space missions opened room for developing processing platforms able to provide easily and efficient data access and visualization as also to enable delivery and analysis of high-level scientific data products.

We propose the implementation of a new VESPA (Virtual European Solar and Planetary Access) application using the MATISSE (Multi-purpose Advanced Tool for the Instruments of the Solar System Exploration) web-tool, to handle the computation of aerodynamic coefficients of non-spherical convex objects.

The coefficients describe the motion of these objects in rarefied gas field present in various astrophysical environments as for example protoplanetary disks and cometary coma. Most of the state-of-the-art cometary gas-dust dynamical models use spherical particles. The new application will provide the aerodynamic coefficients for convex objects and "averaged" ones ready as inputs to the spherical dust codes approximating realistic convex object shapes.

Introduction

In contrast to a spherical grain, an aspherical grain experiences not only drag but lift and torque as well. It is usual to represent the aerodynamic force F_{aas} the sum of its components parallel to the gas velocity relative to the grain, i.e. the drag force D and of its component transverse to it –the lift force L. Then it is common to introduce dimensionless aerodynamic coefficients – the drag C_D and lift C_L:

$$C_D = \frac{D}{1/2\rho V_r^2 S} \quad ; \quad C_L = \frac{L}{1/2\rho V_r^2 S}$$

where $Vr = Vg - Vd$ is the gas-grain (center of mass) relative velociity vector, ρ is the gas mass density, $\rho V_r^2/2$ is the dynamic pressure, and S is a shape-dependent characteristic cross-section. The calculation of these coefficients in rarefied gas field is necessary to compute the motion of dust in different astrophysical physical conditions (e.g. protoplanetary disks of cometary environment). The detailed description of the approach we take for computation of the aerodynamic coefficients is described in [1].

1. VESPA and MATISSE tool

VESPA, within the H2020 Europlanet project, developed such an infrastructure and deals with implementation of new data services [2]. Although VESPA activity is focused on derived archives of calibrated data from ground-based observations and space missions, the VESPA interface (http://vespa.obspm.fr) demonstrates capability of comparing observations and simulations entirely in a Virtual Observatory (VO) environment. For simulations that generate moderate data volume, such approach is feasible, and can even accommodate simulation results of different scenarios or inputs.

MATISSE (Multi-purpose Advanced Tool for the Instruments of the Solar System Exploration) is a web-tool developed for the 3D visualization of small bodies shape models, single observations or real-time computed high-order products [3]. Here, we discuss a new functionality integrated in MATISSE that can provide computed aerodynamic parameters and their visualization using an input data from a dedicated future VESPA service. MATISSE connects with VESPA through a Simple Application Messaging Protocol (SAMP).

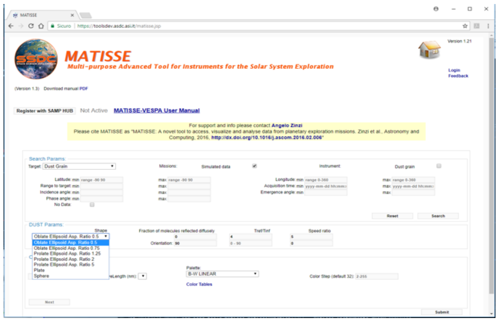

Figure 1. MATISSE view of the interface with the input dust parameters which the user chooses to call real time computation of the aerodynamic coefficients.

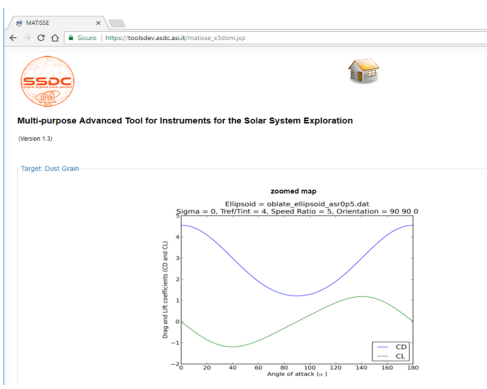

Figure 2. MATISSE view of the plot of the aerodynamic coefficients versus the angle of attack, i.e. the angle between the gas flow direction and the axis perpendicular to the axis of rotation of the dust grain.

2. Real-time computation and visualization of aerodynamic coefficients

The implementation of the aerodynamic application is based on the approach by [2] and provide the following functionality: 1) choice and visualization of the irregular object shape (Figure 1); 2) choice and visualization of the Euler solution of ideal gas flow; 3) real-time computation (if not available as precomputed) of the aerodynamic coefficients; 4) plots of the aerodynamic coefficients vs convex objects dynamical parameters (Figure 2).

3. Conclusions

We present the design and implementation of a new scientific real-time application open to the astrophysical community that computes the aerodynamical coefficients of irregular objects in a rarefied gas flow.

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References

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