CERES CRATERINGS AS RECORD OF PRIMORDIAL BOMBARDMENT

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Introduction: We discuss here our ongoing project to study, in view of the Dawn mission, the cratering process in the Main Belt at the time of Jupiter formation. Dawn mission will provide detailed images of Vesta and Ceres surfaces and supply crucial information to constrain their mineralogical and elemental composition through VIR, its imaging spectrometer. Thanks to these data, we will be able to study in depth the crater record on the surface of both asteroids. In this work we prosecute the project started in [1] for Vesta by computing the evolution of a planetesimal swarm and accordingly computing the statistics of craters on Ceres surface. The accretion of Jupiter perturbs the population of planetesimals existing in the young and evolving Solar System. In the model we consider the formation of Jupiter's core, the subsequent gas accretion and the planet displacement due tidal interactions with the nebular gas. In order to study the effects of radial migration, we allowed the giant planet to migrate by different extents during its formation process. Our results show that Ceres should have been bombarded mainly by objects residing originally in the inner part of the nebula - inside the so–called "snow-line" - but there should have been also a smaller family of impactors from the outer part of the nebula.

The model: We studied the dynamical evolution of a set of test particles representing a swarm of planetesimals with a total mass of 2 Earth masses during the formation of Jupiter's core and the subsequent gas accretion and planetary migration phases. The gas accretion and the migration (due to angular momentum exchange with the accreting gas and the surrounding nebula through tidal interactions) are modeled basing on [2]. We considered different cases of radial displacement, namely 0.25 AU, 0.5 AU and 1 AU: we considered our "reference model" the one characterized by a displacement of 0.5 AU. The swarm has been modeled by dynamically evolving 10^4 test particles under the influence of the forming Jupiter over 2×10^5 years by means of an N-Body integrator. The timespan covered by our simulations has been characterized by:

- a *core accretion* phase, which in the simulations was characterized by a timescale of the order of 10^5 years;
- a *rapid gas accretion* phase, starting as soon as the core reaches the critical value of 15 Earth masses. We derived the timescale for this phase through hydrodynamical simulations performed with the code described in [2]: the value we used in the simulations is 5×10^3 years;
- an *asymptotic gas accretion and planetary migration* phase. The last phase is characterized by a slower gas accretion onto the forming planet, accompanied by its radial displacement. We considered different cases of migration since the extent of the displacement strongly affects the swarm evolution.

Results: This model shows that the region where Ceres is located has been crossed by several objects, coming both from the inner (beyond Mars) and the outer (beyond the so-called "snow-line") regions. This second family of impactors could in principle be responsible for the delivery of volatiles in the inner region of the Solar System.

The expected crater distribution on Ceres is different at different stages:

1. at the beginning, the crater distribution is dominated by impacts of small rocky bodies that should lead to an intense and uniform craterization;
2. the icy planetesimals contribute less to the craterization, but their impact energies are, on average, higher, therefore contributing to the resurfacing and the thermal histories of the two bodies.
3. Vesta and Ceres observations and crater counting could help in discriminating between different populations of impactors, allowing us to infer the Jupiter dynamical evolution at the epoch of the gas accretion and the gas-driven displacement.

References:

[1] Magni et al. 2008, LPSC, 1571.
[2] G. Magni and A. Coradini, 2004, PSS, 343-360.