

**When minor planets Ceres and Vesta
rock the Earth into chaos**

Based on the article "Strong chaos induced by close encounters with Ceres and Vesta", by J. Laskar, M. Gastineau, J.-B. Delisle, A. Farrès, and A. Fienga

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***Astronomy & Astrophysics* is publishing a new study of the orbital evolution of minor planets Ceres and Vesta, a few days before the Dawn spacecraft enters Vesta's orbit. A team of astronomers found that close encounters among these bodies lead to strong chaotic behavior of their orbits, as well as of the Earth's eccentricity. This means, in particular, that the Earth's past orbit cannot be reconstructed beyond 60 million years.**

Astronomy & Astrophysics is publishing numerical simulations of the long-term evolution of the orbits of minor planets Ceres and Vesta, which are the largest bodies in the asteroid belt, between Mars and Jupiter. Ceres is 6000 times less massive than the Earth and almost 80 times less massive than our Moon. Vesta is almost four times less massive than Ceres. These two minor bodies, long thought to peacefully orbit in the asteroid belt, are found to affect their large neighbors and, in particular, the Earth in a way that had not been anticipated. This is showed in the new astronomical computations released by Jacques Laskar from Paris Observatory and his colleagues [1].

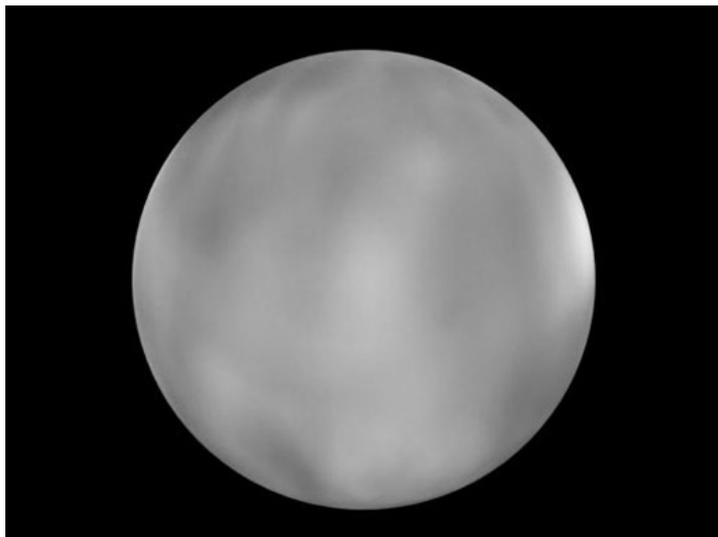


Fig. 1. Observations of Ceres by NASA's Hubble Space Telescope. © NASA, ESA, J.-Y. Li (University of Maryland) and G. Bacon (STScI).

Although small, Ceres and Vesta gravitationally interact together and with the other planets of the Solar System. Because of these interactions, they are continuously pulled or pushed slightly out of their initial orbit. Calculations show that, after some time, these effects do not average out. Consequently, the bodies leave their initial orbits and, more importantly, their orbits are chaotic, meaning that we cannot predict their positions. The two bodies also have a significant probability of impacting each other, estimated at 0.2% per billion year. Last but not least, Ceres and Vesta gravitationally interact with the Earth, whose orbit also becomes unpredictable after only 60 million years. This means that the Earth's eccentricity, which affects the large climatic variations on its surface, cannot be traced back more than 60 million years ago. This is indeed bad news for Paleoclimate studies.

This unexpected discovery comes at a time when both objects are the targets of [the NASA/Dawn mission](#). The Dawn probe will encounter Ceres in February 2015. At present, Dawn is approaching Vesta, and will enter its orbit this coming Saturday, July 16, 2011.

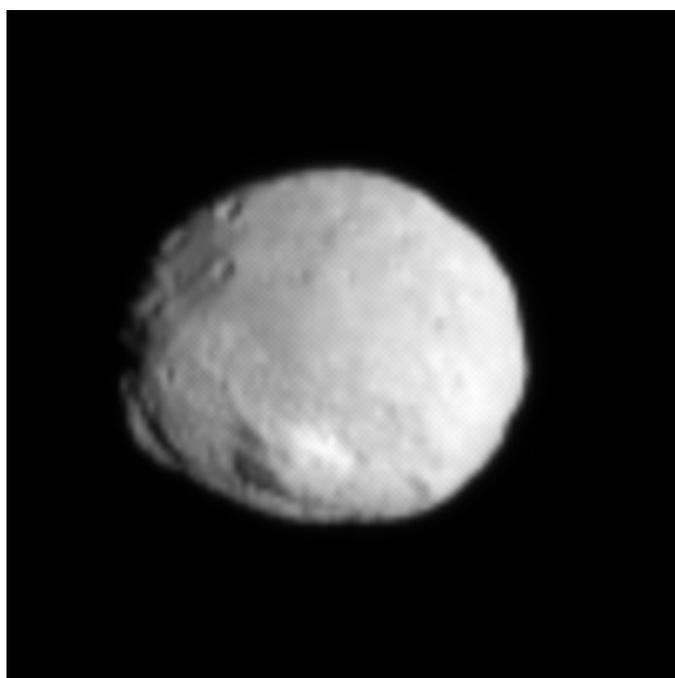


Fig. 2. Vesta. NASA's Dawn spacecraft obtained this image with its framing camera on July 1, 2011. It was taken from a distance about 100,000 kilometers away from Vesta.
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[1] The team of astronomers includes J. Laskar, M. Gastineau, J.-B. Delisle, A. Farrés (IMCCE, Observatoire de Paris, France), and A. Fienga (IMCCE/Observatoire de Paris and Observatoire de Besançon, France).

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