EPSC Abstracts
Vol. 14, EPSC2020-752, 2020
https://doi.org/10.5194/epsc2020-752
Europlanet Science Congress 2020

New estimates of the mass and density of asteroid (16) Psyche

Lauri Siltala[1] and Mikael Granvik[1,2]
[1]University of Helsinki, Department of Physics, Helsinki, Finland (lauri.siltala@helsinki.fi)
[2]Division of Space Technology, Lulea University of Technology, Kiruna, Sweden

Asteroid mass determination is performed by analyzing an asteroid's gravitational interaction with another object, such as a spacecraft, Mars, a companion in the case of binary asteroids, or a separate asteroid during a close encounter. During asteroid-asteroid close encounters, perturbations caused by the masses of larger asteroids can be detected in the post-encounter orbits of the smaller test asteroid involved in such an encounter. This can be described as an inverse problem where the aim is to fit six orbital elements for each asteroid and mass(es) for the perturbing asteroid(s), for a total of 13 parameters at minimum unless more asteroid-asteroid encounters are modeled simultaneously.

To solve this inverse problem, which is traditionally done with least-squares methods, we have implemented a Markov-chain Monte Carlo (MCMC) based solution and recently (Siltala & Granvik 2020) reported, among others, significantly lower than expected masses and densities for the asteroid (16) Psyche in particular. Psyche is an interesting, and topical, object as it is the target of NASA's eponymous Psyche mission and is commonly thought to be of metallic or stony-iron composition, which our previous density estimates disagreed with. In our previous work our two separate mass estimates for Psyche were based on modeling encounters with two separate test asteroids in both cases. Since then we have further refined our mass estimate for Psyche by simultaneously using eight separate test asteroids for this object, significantly increasing the amount of observational data included on the model which, in turn, will narrow down the uncertainties of our results at the cost of additional model complexity. Here we report and discuss our latest results for the mass of Psyche based on this case and compute corresponding densities based on existing literature values for the volume. We obtain a mass of (0.972 ± 0.148) * 10^-11 solar masses for Psyche corresponding to a bulk density of (3.37 ± 0.58) g/cm³ which is higher than our previous results while remaining consistent with them considering the uncertainties involved. It still remains lower than other previous literature values. We compare our results to these previous literature values and briefly discuss possible physical implications of these results.

In addition, due to previous interest from the scientific community, we have also computed mass estimates for Ceres and Vesta, both of which already have very precisely known masses from the Dawn mission. As such, our results for these two asteroids are not of direct scientific interest but they serve as an useful benchmark to verify that our algorithm provides realistic results as we have 'ground truth' values to compare our results to. We find that for both cases, our results are in line with those of Dawn.