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Author: Mr. Norizumi Motooka
University of Tokyo, Japan, norizumi.station@gmail.com

Dr. Osamu Mori
Japan Aerospace Exploration Agency (JAXA), Japan, mori.osamu@isas.jaxa.jp
Dr. Hajime Yano
Japan Aerospace Exploration Agency (JAXA), Japan, yano.hajime@jaxa.jp
Dr. Junichiro Kawaguchi
Japan Aerospace Exploration Agency (JAXA), Japan, Kawaguchi.Junichiro@jaxa.jp

A STUDY ON THE DISTRIBUTION OF DUST PARTICLES TRAPPED INTO A HORSESHOE ORBIT

Abstract

Dermott (1994) predicted that in the rotating frame with the Earth, particle number density is about 10 percent greater at the trailing side of the Earth than in the background cloud of particles. He considered that the specific number density is caused by asymmetricity of dust particles' paths about the Sun-Earth line. Its asymmetric paths are under the orbital resonance with the Earth and general solutions of the restricted three-body problem including solar radiation pressure which involves drag force known as Poynting-Robertson (P-R) drag. This paper assumes that dust particles which are trapped into a horseshoe orbit by the Earth gravity principally contribute to the dust distribution around the Earth orbit. A horseshoe orbit is also a solution of it and has the following characteristics from numerical investigations. The velocity of a trapped dust varies by its location on the horseshoe orbit and the dust will transit with time to wider horseshoe orbit. This paper reveals the distribution of dust particles based on these characteristics.

First of all, the distribution was analyzed on the assumption that dust particles are trapped into a horseshoe orbit. It was found that there are two peaks of density on the orbit. Although one of these peaks always exists at the trailing side of Earth in the rotating frame, the other peak's position depends on where the dust particles are trapped into a horseshoe orbit. To predict this peak's position requires statistical analysis about the trapped locations.

Secondly, we also examined the possibility that a dust is certainly trapped into a horseshoe orbit or not. In our model, two of one hundred particles which originated from the inner part of main belt and had eccentricity of near zero were successfully trapped. The trapped particles move along the horseshoe orbit by drawing small circles, because the particles' orbits have a small value of eccentricity (less than 0.05) in the inertial frame. This eccentricity is yielded by the Earth gravity when dust's semimajor axis gets closer to the Earth's one.

This paper revealed that the trapped location determines the peak's positions of dust particles and also their distributions, and the existence of particles which was trapped into a horseshoe orbit have been confirmed. Clarifying how these particles are trapped in the orbit from intensive investigations leads to the understanding of statistical distribution about the trapped locations and thus the distribution of dust particles.