On the Stability of the L₃ and L₄ Triangular Lagrangian Points of Saturn

F. Téger (ELTE)

Several papers have been written recently investigating the stability of Saturn’s Trojans. Most of these papers treated low inclination orbits, only Zhang and Inmanne (1998c) considered orbits with high inclination. However, they used an idealised model and their integration time was smaller than 100000 year, though we know that the triangular Lagrangian points of Saturn become unstable after 100000 year. Thus the question is, how the orbits will evolve at high inclination if we integrate these orbits for more than 100000 year.

I studied the evolution of about 2000 test particles distributed near the Lagrangian points of Saturn for intervals up to 300000 year in the model of the Sun-Jupiter-Saturn-Asteroid system using a 4th order symplectic mapping method described by Wisdom and Holman (1991). The initial semimajor axis (a) of the test particle was varied from 9.08 to 9.96[AU] with a step of 0.04. I also varied the mutual inclination (iₚ) between Saturn and the test particle from 0° to 88° with a step of 2°. I have found that there is stable behaviour of the test particle only when iₚ ≤ 26° in the case of L₃ and when iₚ ≤ 30° in the case of L₄, while if iₚ is larger than these values the orbits are unstable. In the case of some unstable orbits, particularly at high inclination, I found a very interesting behaviour of the semimajor axis. While at the beginning the semimajor axis varied in an irregular way, after a few hundred years became stable around the initial value. In order that the semimajor axis remain in the neighbourhood of its initial value, the eccentricity has to increase to a high value, in general above 0.3. I have integrated these orbits for a time longer than 300000 year, and I found that after a few tens of thousand years they became chaotic. Therefore we can say about these orbits that they are temporarily coorbital. The eccentricity plays an important role in the behaviour of the orbits, in most of the cases the sudden increase of the eccentricity leads to instability, but in a few cases this increasing is accompanied by a temporary stability.

The grant OTKA F030147 of the NRF is acknowledged.

Session 21: Science and Technology of Future Space Missions I

Special Contributed Oral Parallel Session
Chair: D. Crisp, R.S. Saunders
8:30-10:00am, Sala Astrolabio

21.01

The MESSENGER Mission to Mercury (Invited)

R. L. McNew, Jr. (APL/JHU), S. C. Solomon (DTM/CITW), MESSENGER Team

Mercury holds answers to several critical questions regarding the formation and evolution of the terrestrial planets. Determining the composition of Mercury, with its anomalously high ratio of metal to silicate, will provide a unique window on the processes by which planetesimals in the primitive solar nebula accreted to form planets. Documenting the global geological history will elucidate the role of terrestrial planet size as a governor of magma and tectonic history. Characterizing the magnetic field and the size and state of Mercury’s core will advance our understanding of the energetics and lifetimes of magnetic dynamos in solar system bodies. Determining the volatile species in Mercury’s polar deposits, exosphere, and magnetosphere will provide insight into volatile inventories, sources, and sinks in the inner solar system. The MESSENGER mission to fly by and orbit Mercury will accomplish all of these key objectives. After launch by a Delta II 7925HL, an Earth flyby, two flybys of Venus, and two flybys of Mercury, orbit insertion is accomplished at the third Mercury encounter. The instrument payload includes a dual imaging system for wide and narrow fields-of-view, monochrome and color imaging, and stereo; X-ray and combined gamma-ray and neutron spectrometers for surface chemical mapping; a magnetometer; a laser altimeter; a combined UV-visible and visible-near-infrared spectrometer to survey both exospheric species and surface mineralogy; and an energetic particle and plasma spectrometer to sample charged species in the magnetosphere. During the flybys of Mercury, regions unexplored by Mariner 10 will be seen for the first time, and new data will be gathered on Mercury’s exosphere, magnetosphere, and surface composition. During the orbital phase of the mission, one Earth year in duration, MESSENGER will complete global mapping and the detailed characterization of the exosphere, magnetosphere, surface, and interior.

21.02

SMART-I: Precursor for the Exploration of the Solar System with Electric Propulsion (Invited)

G.D. Racca, B.H. Foing (ESA/ESTEC)

Deep Space exploration was initiated by a series of fly-by missions that were propulsively and energetically modest. Therefore, the basic energy barrier given by the use of chemical propulsion system was not obstructive. In addition, the use of gravity assists has enabled deep space missions with enlarged velocity increments. Unfortunately, multiple gravity assists have the drawback to narrow dramatically the launch windows and the cruise phases are extremely long with obvious impacts on the operation costs. The most promising solution for the future deep space missions is found in the use of the Electric Propulsion (EP). Thanks to its high specific impulse, the EP enables very high velocity increments, higher payload ratios and the use of smaller launchers. In addition it allows to have more flexible launch windows and ultimately reduces the cruise time.

SMART-1 is a mission to test the system aspects of primary EP. It will be launched as an auxiliary passenger in late 2002 by an Ariane 5 rocket into a Geo-stationary Transfer Orbit. The planetary target orbit is around the Moon, polar, elliptical, roughly 1000 × 10000 km with pericentre near the South Pole. The Moon will be reached after a cruise of 15 to 18 months and providing a velocity increment of about 3.5 km/s by EP. The transfer trajectory makes use of Moon resonances and Moon swing-by’s to test these techniques for future deep space missions. The EP engine is a stationary plasma thruster, providing a relatively high thrust of 70 mN with an input power of 1350 W and with a specific impulse of 1600 s. The scientific observations of the lunar surface will be carried out with a novel X-ray spectrometer and a low mass, very compact IR reflectance spectrometer, together with an imaging camera. An X-Ka-band transponder will allow to perform spacecraft tracking with high accuracy and, combined with the camera, to test techniques for measuring from orbit the Moon physical librations. During the cruise phase the natural and induced plasma environment will be measured.

21.03

Cassini VIMS after the Earth-Moon Flyby (Invited)

R.H. Brown (U. Arizona)

A report on the results from the VIMS instrument during the recent Cassini flyby of the Earth-Moon system will be given. A description of the expectations for the upcoming Cassini flyby of Jupiter will also be reported.

21.04

Mars Express: Mission and Science Goals (Invited)

A.F. Chicarro (Space Science Department, ESA/ESTEC, The Netherlands)

The ESA Mars Express mission includes an orbiter spacecraft and a smaller lander module to be launched in 2003 by a Soyuz rocket. The scientific objectives of the orbiter spacecraft include: global high-resolution photogeology at 10 m resolution, global mineralogical mapping at 100 m resolution, global atmospheric circulation and mapping of the atmospheric composition,