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THE OSIRIS-REX MISSION AND THE MECHANICS OF ASTEROID EXPLORATION

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Abstract

OSIRIS-REX mission was launched in 2016. The spacecraft will reach its target asteroid Bennu in 2017. This sample return mission is of prime importance in field of asteroid dynamics & control and asteroid geophysics. The seminar briefly introduced the new techniques and research developed recently. Analysis of dynamics near Bennu based on recent developments was also discussed. The prime focus of the talk was to introduce the nasty challenges faced when planning missions to small bodies like asteroids and comets especially Bennu.

Technical Content

Motivation for asteroid exploration is due to the role of asteroids in solution to fundamental questions about origin of minor bodies, relationships between asteroids, comets, meteors etc. Interest has also been stimulated by practical problems like source of extraterrestrial minerals, future space bases etc[1]. The pristine conditions on an asteroid contain a detailed record about eons and eons of evolution of space[2,3].

Amongst the 5, 00,000 known asteroids in solar system Bennu was chosen for the OSIRIS-REX mission. Some of the reasons for this selection are Bennu's distance and inclination relative to earth, carbon rich mineral composition and the famous equatorial ridge. Bennu is also of prime importance since its discovery in 1999 because of its classification as dangerous Near Earth Object (NEO) with non-negligible probability of impact. The parameters of interest to understand geophysical characteristics of Bennu are its shape, spin state, gravity field, spectra, topography, surface morphology and surface distribution of regolith. All these observations can lead researchers into theories of formation of Bennu and more in general of asteroids[4,5].

Orbital mechanics near small bodies like Bennu deals with strongly perturbed environment near such bodies. This highly perturbed environment is due to cumulative effect of non-uniform gravity field of the target body, solar radiation pressure and third body perturbations. However, the mechanics around small bodies is dominated by gravitation regime and radiation pressure regime[2]. Analyzing equations of motion while considering effects of gravity and solar radiation pressure together is a mathematically complex exercise. Hence, solutions of equations of motion are often computed separately for different regimes and later analyzed for their combined effect. However, it is often found that stable periodic orbits obtained considering gravity regime individually are unstable when effects of solar radiation pressure are considered. This is one of the challenges of developing a stable trajectory to small bodies. OSIRIS-REX spacecraft will also face similar challenges on approach to Bennu. However, as demonstrated by Dr. Scheeres, even amidst these uncertain environments certain periodic orbits are possible. But as mentioned by Dr. Scheeres, real challenge is the sensitivity of stable orbits to initial conditions. Mere displacement of 100 mts in initial conditions can lead to impacting trajectories.

Current a priori geophysical model of Bennu is based on earth observations of this asteroid. The minimum deviation of this model from actual environment of Bennu is extremely essential for the success of OSIRIS-REX mission. However, navigation and control strategies of OSIRIS-REX regularly update their understanding of Bennu as it approaches near. This new robust control strategy developed for this mission helps us to overcome the inefficiencies of inaccurate models and data collection[6]. Previous asteroid missions to asteroid Eros and Itokawa are excellent records of possible failure modes during asteroid missions. The failure of sample collection mechanism of Hayabusa spacecraft[1] on Itokawa asteroid urged us to develop new sample collection technologies for this mission.

In Conclusion, OSIRIS-REX mission to Bennu is fraught with challenges. However, current analysis and technologies developed for mission take into account these failure modes and are quite robust to succumb to them. But despite of this, partial success of mission to Bennu lies in unveiling the secrets of early origins of solar system and asteroid formation.

Presentation

The talk delivered by Dr. Scheeres was filled with exciting research done by his team and at the same time was thought provoking. Given his good teaching background, Dr. Scheeres was successful in providing excellent clarity of complex topics even in such a short presentation. However, Seminar should have focused more on finding gravity potential fields of non-spherical small bodies and the complex math behind it.

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HONOR CODE:

I declare on my honour that I attended the full seminar until the end. I also attended the question and answer session at the end of the talk.