Regular Mechanism of the Formation of Asteroid Satellites. N. N. Gorkavyi, Greenwich Institute for Science and Technology, P.O.Box 797, Haymarket, VA, 20168, gorkavyi@gist.us

Introduction: After long period of skepticism, the existence of asteroid satellites was observationally confirmed [1]. Now binary asteroids and asteroid satellites have been detected in a variety of dynamical populations, including main belt and Near-Earth asteroids, Trojans and transneptunian objects.

The formation of asteroid satellites is interesting problem, which must be considered in framework of cosmogony of asteroid belt.

Origin of the asteroid belt is the result of collective action of next dynamical mechanisms:

1. Collisions between asteroids and micrometeoroids lead to ejection of clouds of micron-size dust.
2. Solar radiation pressure transfers aphelia of dust's orbits into Jupiter zone [2].
3. Half of small particles quickly escape into interstellar space by scattering on Jupiter gravitational field [2].

As result, more than 99.9% of the mass in the asteroid belt was lost and accretion time was drastically increased. Mass flow is proportional to the area of asteroid surface and the relative mass loss is larger for small asteroids.

Intensive dust flow from asteroid surface is key factor of the formation of asteroid satellites.

Regular formation of asteroid satellite: We propose multi-impact model which explains the origin of asteroid satellites and binary asteroids without space catastrophes [3]. Basic statements of new model:

1. Initial low-mass prograde protosatellite disk or cloud was collected around the asteroid.
2. Most of satellite material was ejected from asteroid surface by many impacts and microimpacts. Efficiency of ejection depends from speed of asteroid rotation.
3. Collisions of ejected debris with particles of prograde protosatellite disk/cloud stabilized ejected debris on satellite orbits. Due to planet rotation volume of prograde debris is larger than retrograde debris.

We showed high efficiency of this mechanism: surface debris, which ejected into prograde orbits, easily joined to prograde protosatellite disk, but retrograde debris immediately returned to surface of the asteroid [4]. Calculations of ballistic transfer of angular moment [4, 5] show that protosatellite ring/cloud must have the radius that is close to average semi-major axis of debris orbits: ejected debris pushes away a smaller ring and decreases moment of larger ring.

Testable predictions from regular multi-impacts model are:

1. Most of satellites of asteroids must have prograde and circular orbits that close to equator.
2. Asteroids with satellites must have faster rotation than single asteroids.
3. Most slow rotated asteroids (or earth-like planets) don't have satellites.
4. For same conditions, relative mass of satellites can be larger for smaller asteroids.
5. Crater' dichotomy discovered for the Moon must be typical for the Charon and large satellites with rotation that synchronized with the mutual orbital motions.
6. Asteroid satellites must have spherical shapes and chemical and geological signatures of many eject' events from the asteroid surface.

Confirmation: Analysis of spin rates of binary asteroids confirms predictions of the new model [6]. Average period of rotation for main belt asteroids is 14.04 +/- 1.26 h (single objects) and 6.46 +/- 0.999 h (12 binary objects). For NEA: 13.51 +/- 2.22 h (single objects) and 3.46 +/- 0.71 h (20 binary objects).

From analysis of first dozen of asteroid satellites with known orbital parameters (eccentricity and inclination) we can conclude that almost all asteroid satellites show signatures of regular origin: low eccentricities and inclination, quasi-spherical shape. Even small km-size Dactyl (Ida's satellite) demonstrates spherical shape in contrast with irregular primary body.

Hypothesis about relatively large satellites of small asteroids looks reasonable, but analysis must be done separately for different populations of asteroids.

Earth-like planets (Moon-Earth and Martian satellites) also support this model: direction of rotation of satellites is prograde only. Most of Moon' material was ejected from Earth' mantle by many impacts of large asteroids. This mechanism explains deficit of iron on the Moon as in Hartmann-Davis model, but avoid numerous dynamical and chemical problems of "mega-impact model" [7].

References:

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