COLLISIONS OF COMPONENTS OF A BINARY ASTEROID DURING LONG-TERM EVOLUTION

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Introduction: Non spherical form of asteroids, constituting a binary system, causes the exchange between their own (spin) and orbital angular momentum as well as between their rotational and translation energies. This effect, competing with meteoroid impacts and radiative effects, can shrink the mutual orbit of asteroids and provoke their collision. For example, near 25 % of cases in numerical model [1] result in collisions. However the fate of binary systems after the component collisions in the model [1] is not considered. We suggest an approach to describe inelastic collisions of non spherical asteroids during long-term (up to 10^4 yr) evolution of binary system.

Approach: Every asteroid is represented as a rigid body consisted from fixed number (typically 22) of balls with hexagonal packing. The typical deviation from spherical form is 15-20 %. Only gravitational and elastic forces are taken into account. The influence of the Sun, planets and other bodies is not considered. Inelastic collisions are described via modification of Hertz formula for repulsive force between balls, offered by authors. The typical Young's modulus is 10^8 dyne/cm^2 and residual deformation is 99 % from the maximal value. The motion equations of rigid bodies are written in inertial frame. The body rotation is described by the Rodrigue's formula of finite turn. The Cauchy problem for motion equations is solved numerically with the help of Runge-Kutta-Merson method of the 4-th order.

Initial conditions are calculated from observable separated (not contact) state of binary asteroids, using the Kepler problem. The observational parameters are: semi-axes and eccentricity of mutual orbit, average diameter of every component, orbital and spin periods [2]. Initial inclination i_0 of orbital plane to the rotation axis of primary component is free parameter. Initial rotation direction of secondary component, its position (periapsis or apoapsis) and initial orientations of the bodies are random.

Results: We allow the system to evolve due to gravitational interaction. It causes the exchange between own and orbital angular momentum of non-spherical bodies as well as between their rotational and translation energies. The system dynamics is stochastic due to irregular form of the bodies.

In some cases the mutual orbit expands: the minimal distance between components increases. When it exceeds Hill radius the system disintegrates. In some cases the mutual orbit shrinks: the minimal distance between components decreases. If contact occurs the elasticity force is switched on and asteroids begin to repulse each other. However elasticity force rapidly switched off due to plasticity after maximal indentation of balls. Therefore asteroids create a contact system in some cases or fly away in other cases. Average (over members and initial conditions) frequency of systems disintegration exceeds the average frequency of contact systems formation in a few times.

In some cases the systems survive during the evolution despite the significant events such as close approaches between components. However we have not found cases where the systems survive after at least one collision. Note that a system can undergo multiple collisions and bounces before disintegration or contact.

The behavior of the systems depends on inclination i_0: the systems are more stable to disintegration or contact in the case of reverse satellites (i_0=180°). The system Ostro is unstable in all the simulations and shows the formation of contact system during several months. This result supports the Johnston's decision to include Ostro into candidate contact asteroids [3].

Conclusions: Our numerical model shows that collisions of asteroids in a binary system lead to formation of contact system or disruption of binary system. The system disintegration is more probable than contact system formation in a few times. The cases when binary system survives after component collisions are not found.

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