Generation of the Moon and Some Other Celestial Bodies due to Explosion in Planet Interiors

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Abstract: It is difficult to explain an origin of all celestial bodies of the Solar system due to smooth evolution of the protoplanet cloud. An alternative to the evolutionary one is the hypothesis of their explosive origin. It is supposed, that on the solid inner core of a planet the active layer is formed from particles of uranium and thorium oxides, weighed in liquid iron of the outer core of the planet. The explosion in such a layer might occur as a result of collision of the planet with an asteroid. Collision of the protoplanet with an asteroid, the subsequent explosion in an active layer and fragmentation of the planet in conditions of gravitation is numerically simulated. for two-dimensional non-stationary motion of the compressible medium on the basis of laws of conservation of mass, pulse and energy. The hypothesis that some bodies of the Solar system may be formed as a result of nuclear explosions in the protoplanet core is numerically confirmed in the paper. If the initial velocity of protoplanet rotation is small enough, the structure and composition of fragments may be determined by the cumulative jet going from a planetary core to its surface. The origin of Io may be so explained, for example. For the great enough velocity of rotation the nuclear explosion in the planet interiors breaks the balance between the centrifugal forces and the gravitation. That results in the separation of the great mass of the stone-silicate shell of the planet and the generation of satellites like the Moon.

Key-Words: numerical simulations, active layer, celestial bodies, explosion, cumulative jet, planet rotation

1 Introduction

Recently the problem of multiphase interactions is one of the most important and developing areas of fluid mechanics (see, for example, 4th WSEAS Int. Conf. on FLUID MECHANICS (FLUIDS'07), Gold Coast, Queensland, Australia, January 17-19, 2007 ; or 2nd WSEAS Int. Conf. on APPLIED and THEORETICAL MECHANICS (MECH '06), Venice, Italy, November 20-22, 2006). Especially, when it is connected with celestial body mechanics.

One of the most complicated and debatable problem of cosmogony is the question on a genesis of the Earth, the Moon and some other celestial bodies of the Solar system. Existing notions about an origin of planets and their satellites are reduced to five basic groups of hypotheses: the first meteoritic hypothesis [1], the second meteoritic hypothesis [2], comet one [3], hypotheses of mega-impact and macro-impacts [4, 5], hypotheses of explosion [6-8].

Within the framework of meteoritic hypotheses, planets are supposed to be formed due to accretion of planetesimales, similar to meteorites (chondrites), which are considered as initial condensates of a proto-solar nebula. These hypotheses are strongly criticized recently. According to the petrography data, chondrites represent the magmatic formations connected to long evolution of planets, and may not be considered as initial condensates, some of them (carbonic chondrites) are changed by the processes of hydration and oxidation and contain adjournment of secondary carbon substances.

This disadvantage is eliminated in the third hypothesis where masses of firm comet-like substance consisting of ice with distributed dust iron-silicate particles are considered as initial planetesimales, which planets were formed of. In the processes of planet accretion and gravitational compression there was a fusion of substance in their interiors and the subsequent internal stratifying of planets into iron-stony core and powerful fluid shell around it. This hypothesis is well satisfied with common nebular theory of the origin of the Solar system and explains some fundamental features of its structure, when all planets are disposed in one and the same ecliptic plane, going through the equatorial plane of the Sun, they move around the Sun in the same direction, which the Sun rotates in. Besides, the composition of fluid shells of some

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planets (Jupiter, Saturn) does not differ significantly from the Sun composition (hydrogen planets). All this confirms generality of the origin of bodies of the Solar system and it is a strong point of the comet hypothesis (as well as meteoritic ones).

However not all features of the structure of bodies of the Solar system may be explained by three hypotheses mentioned above. Mass concentration of iron inside the Sun and planets of the terrestrial group is approximately identical and varies within the limits of 0,3-0,4. However, concentration of iron in Mercury exceeds 0,6. On the contrary, the Moon does not have massive iron core, its average density is close to one of silicates. Along with that, the chemical composition of the Moon is very close to one of the stone shell of the Earth [8]. The chemical compound of satellites of Jupiter is essentially various and also differs from the structure of an external shell of the planet core. The closer to Jupiter, the concentration of iron in the interiors of its satellites is greater, increasing from the minimal values for satellite Callisto (having average density about 1,5 g/cm^3) up to maximal ones for satellite Io, the latter ones are close to the concentration for Mercury. The fourth hypothesis (mega-impact) became rather popular recently. According to it, an oblique impact of the Proto-earth and Mars-like body took place. The subsequent accretion of substances from a cloud of stone particles, thrown out by the impact from silicate Proto-earth shell and from the body material, has resulted in formation of the Moon in a circumterraneous orbit. In this way it is possible to explain the similarity of the Moon composition and the one of the Earth stone shell. The numerical modeling of the process [4] confirms an opportunity of such a mechanism of satellite formation, though the probability of this phenomenon is very small, and apparently not all the satellites of planets might be formed in a similar way. Jupiter, Saturn and other giant planets have some massive satellites and it is necessary to assume the existence of many planets chaotically moving in the Solar system, colliding with other planets and forming satellites. That seems quite improbable. The small probability of such an event is eliminated within the framework of the theory of macro-impacts (closely related with the mega-impact hypothesis) [5]. The critical analysis of the mega-impact is combined there with its developing, and the model of much smaller sizes of an impact body is offered. Though consequences of such interaction do not generate massive enough bodies with abnormal characteristics any more.

The existence of a belt of asteroids between the orbits of Mars and Jupiter is usually attributed to the full destruction of the Proto-planet (Phaeton), existing earlier in the area. The destruction had a character of an accident [8], finding an explanation within the framework of the fifth group of hypotheses (explosive ones). The differentiation of substance in planets during evolution (sedimentation of heavy elements to the center of a planet and an exit of light fractions to its surface) should result in the acceleration of a planet rotation. Infringement of a balance between forces of gravitation and centrifugal forces may lead to a gravitational explosion [8] and subsequent loss of an essential part of the mass by the planet. Therefore, the disadvantages of such an explosive hypothesis are (1) too great necessary speed of rotation (one rotation for less than hour) and (2) impossibility of full destruction of a planet.

The other group of explosive hypotheses [6, 7] explains an origin of some celestial bodies by a nuclear explosion inside some Proto-planets which fragments became germs of celestial bodies with unusual characteristics and abnormal chemical composition. Obvious traces of natural chain nuclear reactions, taking place more than 2 billion years ago are found out in the Western Africa [9], but the mode and consequences of such explosions for the Solar system have not been considered yet.

According to [6, 7], an active layer, composed by particles of uranium oxides or carbides weighed in a liquid iron, is formed at a planet core (or in the core [10]) due to the processes of substance differentiation. The explosion in such a layer might take place at fast and deep transition of the system in a supercritical state. Namely, when fast relative packing of the layer of the uranium dioxide particles and other fissile isotopes, distributed in a liquid iron, takes place. The shock wave (SW), having sufficient capacity for this purpose, may arise at a collision of the planet with a big asteroid having the diameter of about 100km.

Mathematical modeling of a planet fragmentation at active layer explosion in conditions of gravitation is an object of this research.

2 Formulation of mathematical problem

As it was found out in [11] condensation of particles occurs in a wave reflected from a rigid wall (a firm planetary core), or at the exit of a wave from the core into the two-phase mixture ("piston"). At the regions, where SW, initiating explosion, goes along a surface of the core, no essential packing of particles and growth of their mass concentration

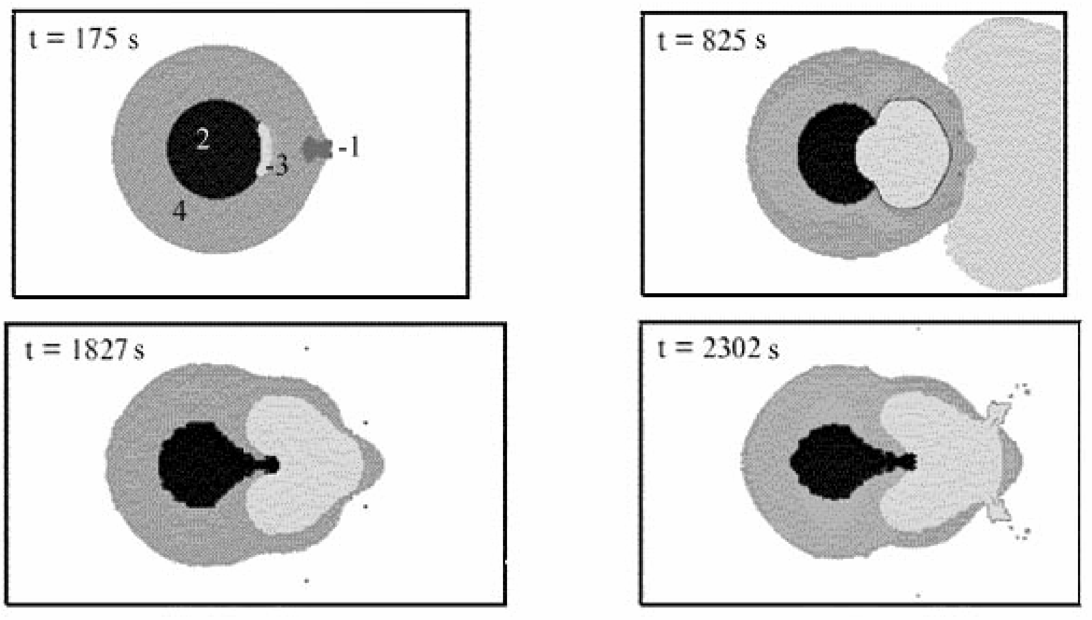

Fig. 1. Dynamics of formation of the cumulative jet in interiors of the planet and its influence on the process of the fragmentation.

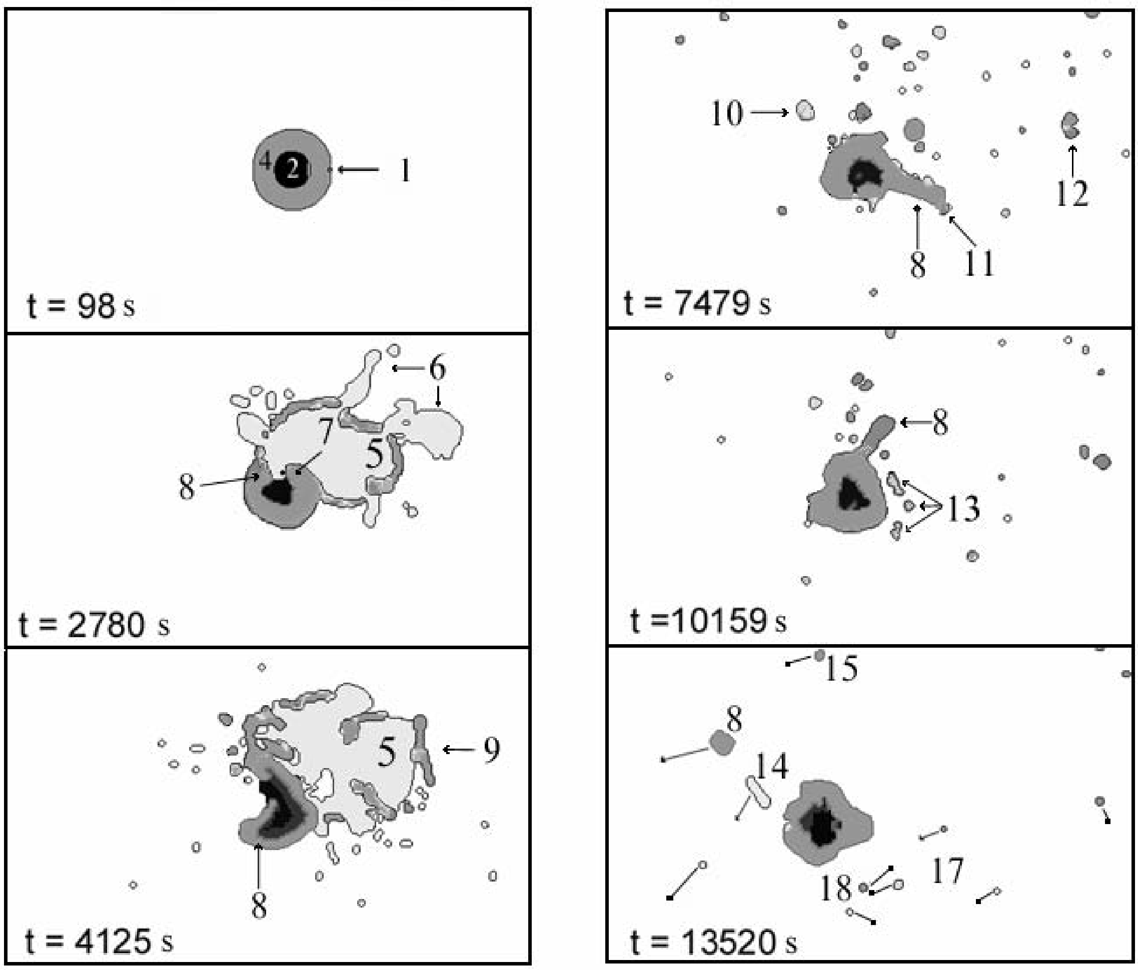

Fig. 2. Fragmentation of quickly rotating planet.

spherical cave (filled with explosion products, plasma) is forming on the surface of the planet core (body 3, t = 825 s). The maximal value of pressure in the planet core achieves 2204 GPa. Then collapse of the cave occurs due to gravitation (t = 1327 s). That results in generation of cumulative jet from the substance of a planer core. The longitudinal flow velocity in the jet is much higher than in other regions of the planet. It achieves values of 7km/s. For liberated energy equal to $3{\cdot}10^{21}$ MJ it is not enough for the emission of substance from the core into the interplanetary space. By instant *t*=2302s the velocity *u* in the jet falls up to zero, and it begins to be involved back in the core. For greater values of explosion energy ($6{\cdot}10^{22}$ MJ) the jet breaks the stony shell of the planet and comes into interplanetary space, where it disintegrates into fragments.

At the increase of the rotation velocity, the shape of the explosive cavity on the core surface is deformed and loses the symmetry. That process weakens the velocity of the cumulative jet and reduces a bulk of the substance in it. When $\lambda \in (3{,}21{\cdot}10^{-4};4{\cdot}10^{-2})$ the cumulative jet becomes weak and doesn't come through a planet stony core. Nevertheless during the process of planet destruction, a multitude of a stone fragments (quite little in comparison to R_0) come into an orbit round the planet similarly to the previous case. At values of λ close to the upper bound of the interval the jet practically does not influence the process of the destruction.

At further growth of λ (λ >0,04) the process of fragmentation becomes essentially different from one described above. At the period of the rotation is 3 hours (λ = 0,11) the results of calculations are submitted in Fig.2., where the planet rotates in a positive direction (counter-clockwise). The other initial data correspond to the case considered above. The darker colors of the areas in figure correspond to the higher values of the density. As well as at the absence of rotation, the gas-dust plume (1) is formed from the substance of the asteroid (though it is irregular-shaped here). The values of density and pressure in it fall down quickly. By the moment *t*=1600s it ceases to influence the process of the fragmentation. When *t*=2040s, the jets of plasma (bodies (6)) begin to break off the stone shell of the planet, starting the process of its fragmentation. It is visible from the figure that the cavity on the core surface is insignificant, and the cumulative jet is not generated. The pressure in the products of the nuclear explosion (5) quickly falls down, and at *t* > 1500s in the vicinity of the core the great bulks of the planet stone shell (the regions (7) and (8)) begins to move towards each other through the region (5), owing to the processes of the gravitation and the rotation. After their impact at *t* > 3100s the bulks begin to move in the opposite directions. Owing to the planet rotation, the region (7) practically stops, the area (8) gets additional great kinetic energy and begins to go away from the center of mass of the system, keeping the angular velocity of rotation as a whole.

The velocity and tension flow-fields are unsteady in the generated splinters. Therefore the process of the splinters crushing proceeds. This is visible from the evolution of bodies (9) and (12), which go away from the planet. Part of the fragments does not receive sufficient kinetic energy at the explosion and comes back to the planet due to the forces of gravitation, as the splinter (10), for example. The region (8) rotates with the planet; its centrifugal forces exceed the influence of the gravitation. So it gradually comes off the center of mass. The evolution of the body (11) seems to be interesting. It goes along the orbit in a direction opposite to the planet rotation. At *t* > 7000s there is an impact (practically on a tangent) of this splinter with the region (8) of the planet. The velocity of their mutual approaching exceeds 12 km/s. Arising from the sliding bodies and also due to the gravitation, essentially non-equilibrium field of the pressure in the splinter (11) and in the superficial layers of the region (8) results in the full fragmentation of the body (11) and some parts of the area (8) and the generation of the cloud of small splinters (13). Part of splinters (13) subsequently drops on the planet. This phenomenon is known in cosmogony. At the approaching to the planet in distance less than critical one, some satellites break out to the small fragments (the criterion of Rosh). If the velocity of the satellite was great enough, the most part of the fragments remains in the orbit, generating the rings similar to ones of the giant planets: Saturn, Jupiter and Uranus.

The arrows at the final stage of the process in Fig.2 show the value and the direction of the vector of the fragment average velocity. By the instant *t*=12450s the speed of substance in the region (8) exceeds 10 km/s, and the separation of a large stone-silicate fragment occurs. Average diameter of the generated splinter is about 0,273 of the initial diameter of the planet (the ratio of the diameters of the Moon and the Earth is equal to 0,272). It comes to the strongly extended eccentric orbit. It is interesting, that at the exit into the circular orbit, the splinter would be turned to the planet by the one and the same side, since up to the moment of the separation linear speeds of substance in it and superficial layers of the planet coincide. Owing to the gravitational influence of the Sun and other planets curvature of a trajectory may vary further. The composition of the fragment is identical to one of the stone shell of the Proto-planet, and the direction of its movement coincides with one of the planet rotation. Thus, the fragment has some properties similar to ones of the Moon. So it is quite probable, that generation of the Moon occurred similarly. At the separation, the plenty of small splinters is formed (the body (14)) as well, which move along the trajectories more close to the planet. Except the large satellite (8), more small fragments come into the orbit also (for example, bodies (15) and (16)). They move around the planet in a counter direction. The same property is also valid for the groups of splinters (17) and (18) which are located closer to the planet. If the bodies (15) and (16) are capable to be kept in the orbit then the bodies (14), (17) and (18) should be destroyed at the interaction and due to the gravitational influence of the planet also (if they approach the planet closer than the limit of Rosh), generating the formations similar to the rings of the giant planets. The difference in the character of the satellites manipulation takes place in the Solar system as well. For example, if Nereida and some other satellites move around Neptune in the direction of its rotation, then the satellite Triton goes in the opposite direction [8].

5 Conclusions

The hypothesis that some bodies of the Solar system might be formed as a result of nuclear explosions in the interiors of some Proto-planet is confirmed in the paper. Modeling has shown that at explosion large enough fragments are formed. They may have mainly iron-nickel or stone-silicate compositions that explains anomaly in the compound and the structure of some planets, satellites and asteroids. The formation of small celestial bodies at the explosion may occur at the preservation of big Proto-planets. Thus the cumulative jet going from the planetary core to its surface may determine the character of the splinters and their composition. So the origin of Io (the nearest satellite to Jupiter), consisting basically from iron, may be explained, for example. Other explanations are failed. If the velocity of rotation of the initial planet is great enough, the cumulative jet has not determining influence on the process of destruction. In this case the nuclear explosion in the planet interiors breaks the balance between the centrifugal forces and the gravitation. That results in the separation of the great mass of the stone-silicate shell of the planet and the generation of satellites like the Moon.

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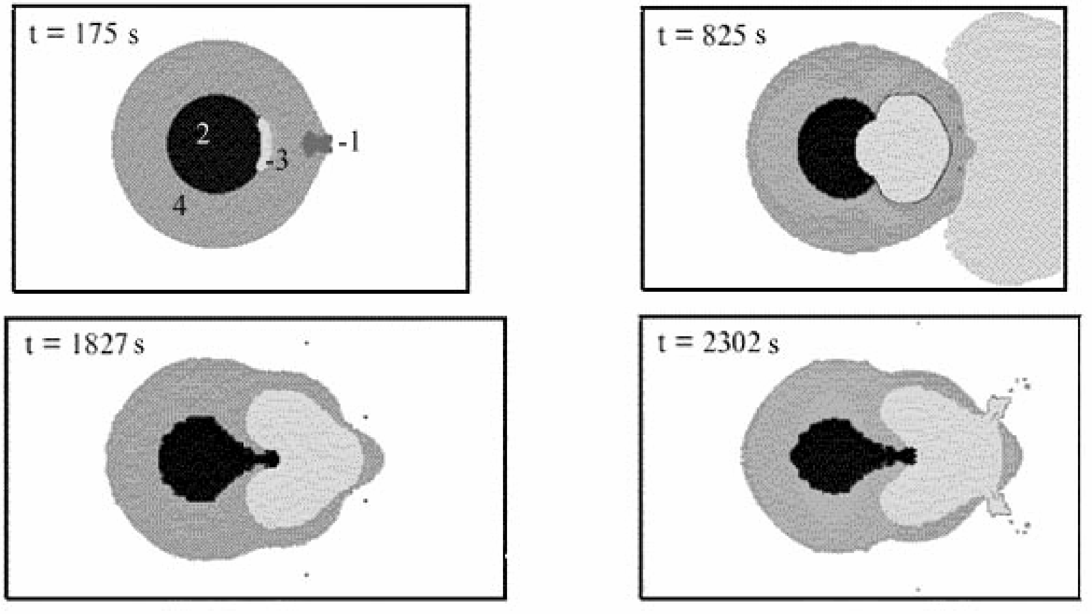

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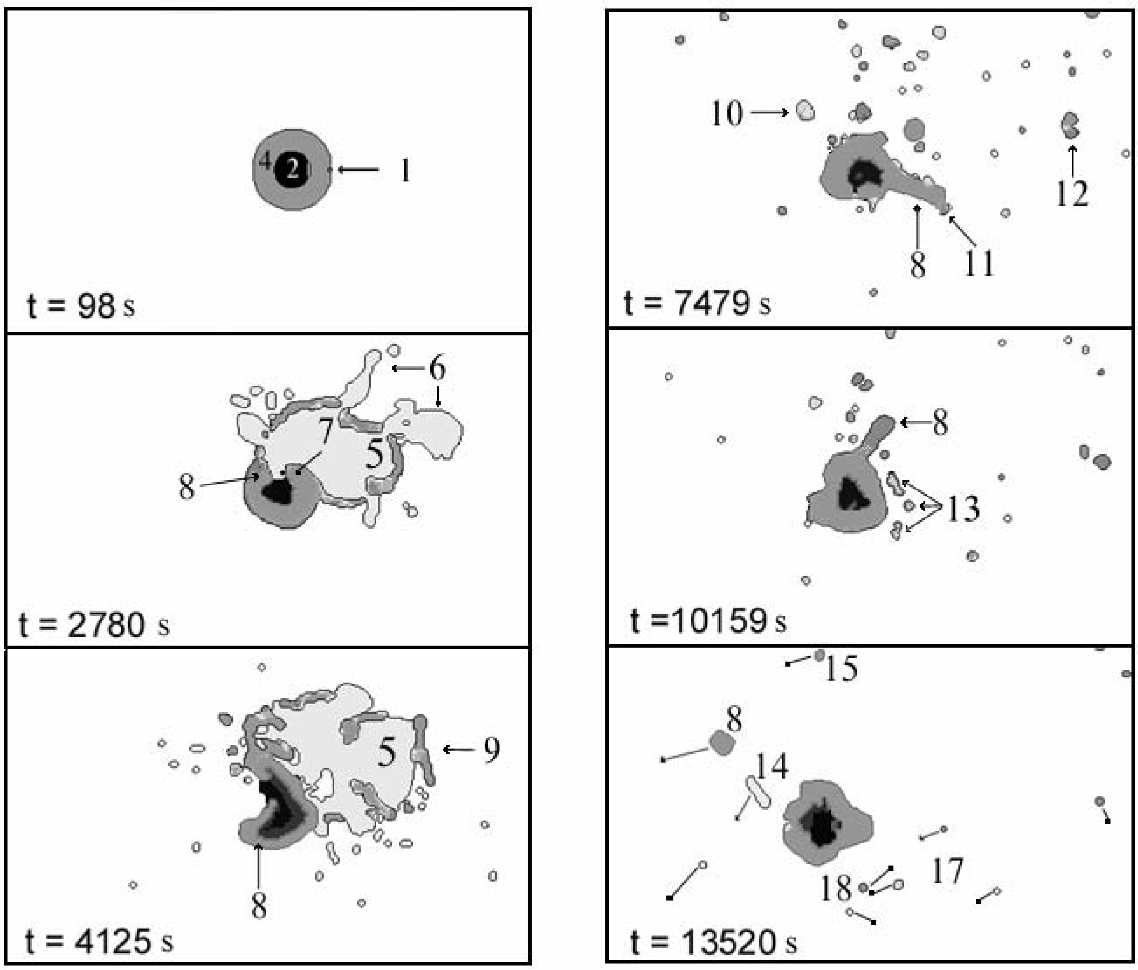

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