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The planet formation hypothesis: Why are the Solar System planets different in their chemical compositions?

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This presentation is an attempt to understand the causes of the principal differences in the mineral composition and chemical and physical properties of the Solar System (SS) planets and to explain some general principal features of the present SS.

From the late 1980s, an opinion exists that the SS arose as a result of interaction between a supernova and a presolar gas–dust cloud. Such a hypothesis is a result of detection of small grains of different chemical compositions with isotopic anomalies in the fine-grained matrix of some primitive meteorites [1]. A number of the researchers believe that the anomalies result from the presolar origin of these meteorites. However, such an explanation is ambiguous. It is quite possible that the anomalies, if they really exist, are caused by peculiarities of the history of some portion of the nebular material inside the supernova. The point is that we have only assumptions about the matter state along the supernova radius, character and rates of the nuclear reactions within the supernova, etc.; we don't know whether the supernova explosion was one-step or multi-step. Besides, new planetary systems arise rather frequently in the Universe. It is unlikely that the occurrence of a presolar gas–dust cloud is necessary for formation of the planetary systems after supernova explosions, because the probability of multiple interactions between two independent phenomena in different regions of the Universe is low.

Meanwhile, we believe that the hypothesis of planet formation should include the simplest conceivable evolution pattern that is rather highly-probable to be multiply repeated in the Universe and should not conflict with the principal features of the SS current state, the last requirement does not relate to the opinions that are disputable and may be mistaken. According to Newton's fundamental rule, nobody ought to presume any natural causes in addition to those true and sufficient to account for phenomena; Nature is simple and does not afford such a luxury.

We consider the simplest hypothetical variant for SS origination from only one parent and discuss the problem how it could be formed as a result of the supernova explosion without interaction with an older gas–dust cloud [2–4].

We subdivide the SS bodies into the physically formed objects (PFO) located in the cold region of SS (from the outside to the today Main Asteroid Belt) and chemically formed objects (CFO) located in its hot region.

The Supernova explosion led to formation of a solar nebula that consisted of atoms, radicals, protons, neutrons, etc. The nebula quickly expanded and, therewith, steadily cooled. In this period, H_2 and other two-atom molecules and hydride radicals formed. With time, the nebula transformed to a flat thin disk composed of many concentric diffusely-bounded rings; the more peripheral they were, the lighter molecules they tended to contain. Most of the lightest He and H_2 molecules and also not so numerous Li, Be, and B atoms concentrated within the cold relict Universe region with the temperature below that of H_2 condensation. Condensation of H_2/He began. H_2/He drops grew, merged together, formed agglomerates that absorbed light Li, Be, B, LiH, BeH, etc. atoms and molecules, which formed the agglomerate cores. Steadily, the agglomerates increased in size, competing with each others for the mass and gravitational attraction. Thus, the process of PFO origination started. At once, the nebula began to collapse to the center of the explosion, obeying the angular momentum conservation law; it collapsed as a whole because its objects were bound by gravity forces. The

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heavy atoms and molecules remained in the nebula section where the temperature was too high for their physical agglomeration and the concentration was too low for chemical reactions to proceed. The system progressively decreased in its volume as a result of the PFO growth and of gravitational attraction to the center of the explosion. Its temperature increased due to evolution of the heat of processes of pressing and condensation. The less was the distance from the central proto-Sun, the greater was the degree of compression and the higher was the temperature. This process and, possibly, nuclear (not thermonuclear) reactions within the proto-Sun led to a critical temperature value in the center of compression and to the "flash" of the Young Sun.

The nebula compression process initiated chemical reactions over the warm region of the nebula, because it led to a heating and to a progressive increase in the concentrations of the heavy particles and in the frequency of their collisions. As the nebular-disc compression increased, chemical combination reactions between metal and metalloid atoms exponentially accelerated. The reactions stimulated localizations of the substances and reaction heat and initiated compressible vortexes, within which hot cores originated, and triggered the process of CFO formation. The reaction heat was capable of melting the cores. In the vicinities of the giant vortexes, low-pressure and gravitational attraction zones arose. They stimulated flows of light cold vaporous and gaseous substances and asteroid-like agglomerates from the outer space and flows of asteroid-like agglomerates of not so light substances from the intermediate regions of the space to the hot cores. The flows precipitated over the hot core surfaces of the CFO and cooled them. The sandwiches obtained as a result of these processes became steadily the young terrestrial planets and their satellites.

H_2 chemisorbs well at different substances, and, therefore, the space dust and agglomerates were filled with it and it was widely distributed over the Earth's crust. Water was mainly captured by the SS objects located at the behind-Mars orbits (the cause of this phenomenon is under consideration). However, some water amounts were captured by the Earth. Within the Earth's crust, water, hydrogen, and carbonates gave methane-hydrate, which, according to [2], was the cradle for the simplest living matter originated from CH_4, niter, and phosphate within its solid structure. The mechanisms of all these hypothetical processes and their thermodynamic consideration is given in [5, 6] and will be presented at the conference.

The PFO–CFO hypothesis allows for understanding why the light elements, such as H, C, N, and O, are concentrated predominantly in the PFO composition at the SS periphery, why these elements exist there, mainly, in the forms of H_2, H_2O, NH_3, and CH_4, and why the less is the mass number of the molecules of each of these substances, the longer is the distance of their most abundant localizations from the Sun. Our hypothesis explains also the absence of light metalloid elements in outer envelope of Pluto and the behind-Pluto objects of the SS.

The PFO–CFO hypothesis leads to the conclusion that the cores of the most remote planets are enriched with Li, Be, and B. This conclusion can be tested in future. Our hypothesis indicates also the possible mechanisms of H_2 and H_2O accumulation in the Earth's crust at the earlier step of planet formation and of the subsequent transformation of H_2 to CH_4 and CH_4-hydrate.

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