The origin of the Moon: a gravitational instability?

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The origin of the Moon has long been of interest and although the Giant Impact theory is currently the preferred explanation, unequivocal supporting evidence has been lacking. The megaimpact model is based on the concept of a collision with the Earth of a body whose mass exceeded one to two Martian masses. Such an idea was suggested by Cameron and coauthors and then developed (mainly numerically) in a number of papers. In our opinion, however, the megaimpact hypothesis belongs to a rare class of catastrophic hypotheses that are based on low-probability random events. Here, we consider an opposite model: a regular evolution process. The formation of the Earth–Moon system is re-examined by considering the stability of the common preplanetary disk of gas and dust with a mass of about $100M_\oplus$ and a radius of about $100R_\oplus$. In the framework of this model, the preplanetary disk forms self-gravitating, massive $\sim (10-30)M_\oplus$, gaseous proto-Earth and proto-Moon through a gravitational instability of the gas, accompanied by settling and coagulation of dust grains to form solid cores. The larger part of the initial mass of the Earth–Moon system as well as the initial mass of protoplanets of the Earth's group were probably blown away due to intensive thermal emission of the early Sun. It is shown that a collective process, forming the basis of the gravitational instability hypothesis, solves with surprising simplicity the two main problems of the dynamical characteristics of the Moon, which are associated with its significant mass and large orbital momentum. Observations should be able to verify the suggested mechanism of gravitational fragmentation by dating the abundances of volatile and low-melting elements: the fragmentation requires the lost of volatiles from the substance of the Moon and all terrestrial planets during some highly energetic process of formation (thermal emission of the early Sun?) that heated the material to very high temperatures.

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