

Comets and the history of our Solar System

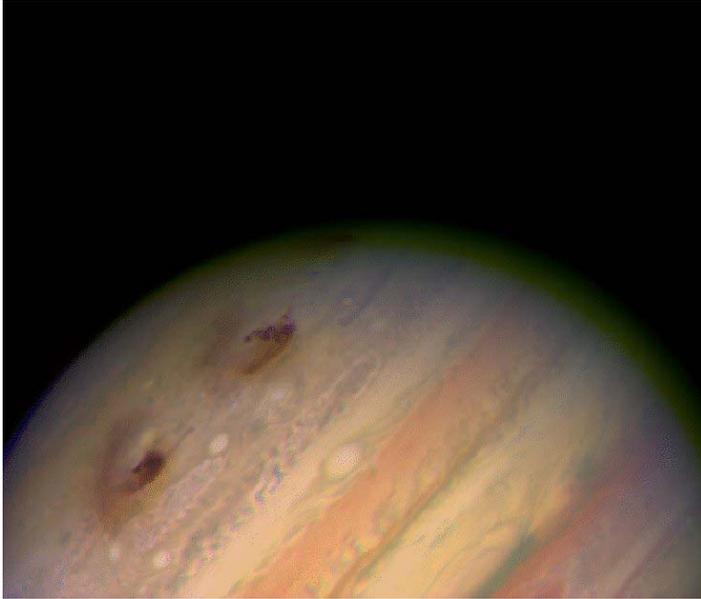
It is generally accepted that the Sun and the solar system were all formed at the same time, when a gas and dust cloud in this part of our galaxy started to collapse under its own gravitational attraction. Initially this gave rise to the young Sun, where thermonuclear fusion reactions just had begun to produce energy, surrounded by a gas and dust disk, similar to those that we observe today around other young stars. This protoplanetary disk then further condensed; planets and moons were formed in the course of time. The planets swept up most of the matter in the inner Solar System. The Sun's heat and the solar wind removed lighter elements like hydrogen and helium, and the regular effect of the gravitational pull of the planets removed most of the solid matter from these innermost regions.

It is believed, however, that the matter in the outer regions of the Solar System (that is, beyond the orbit of Neptune) was largely unaffected. Oort, a Dutch astronomer, postulated the existence of a ring of aggregates of frozen gas and dust in the outskirts of our Solar System. Through small orbital perturbations (for instance, close encounters between several such objects within the Oort cloud) some of these object could be deviated and sent into the inner regions of the Solar System - thus forming comets. This is consistent with the observation that the orbits of many comets are hyperbolic or parabolic, that is, they appear to come from very far, and after one passage near the Sun they journey back into the depths of space.

On the other hand, the chances that the orbit of a comet is modified by the gravitational pull of the planets - especially the massive Jupiter - are not negligible. In this way, comets become "trapped" in the inner Solar System; they revolve around the Sun usually in elongated elliptical orbits. A well-known example is Halley's comet, who returns to the vicinity of the Sun every 76 years; this comet has repeatedly been spotted since ancient times.

Upon every pass close to the Sun, however, the comet is at risk: it loses matter as it leaves dust and gas behind, it might be pulled apart and broken into pieces by the gravitational forces of the planets, its orbit might get perturbed even more by the gravitational pull of the planets, and its orbit is influenced in any case by the non-gravitational forces that accompany the ejection of gas and dust. The life of a periodic comet is therefore limited, and its fate is either to be broken down to pieces completely, to collide with a planet, or to end up in the inferno of the Sun itself. The recent events with comet P/Shoemaker-Levy 9 illustrate this dramatic fate. Jupiter's gravitational field, the cumulative effects of previous mass losses, and the loose binding of the material in the nucleus led to a breakup of the nucleus in different pieces, which eventually collided with Jupiter.





The figure (in visible light, made by the Hubble Space Telescope, courtesy by the STScI Office of Public Outreach) shows two dark spots in Jupiter's cloud tops, scars of the impact of two of these fragments (Fragments G and Q2). Collisions of comets with Earth are a hotly debated topic. In any case, it appears that such collisions might have been more likely in the early history of our Solar System, and could have played an important role in shaping and resurfacing planets and moons.

Since it appears that the comet's nucleus consists of the primordial interstellar matter from which the Solar System condensed, the study of its composition would be of extreme astrophysical importance, as it would give us a perspective on the conditions in which the Solar System - and life - originated.

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