PERIODIC COMET SHOWERS, MASS EXTINCTIONS, AND THE GALAXY

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Geologic data on mass extinctions of life and evidence of large impacts on the Earth are thus far consistent with a quasi-periodic modulation of the flux of Oort cloud comets. Periods of ~26 to 31 m.y. have been derived using various subsets of extinction events, different geologic time scales, and various methods of time-series analysis. In the longer records, the second or third highest peak lies between 35 and 37 m.y. When the phase is allowed to vary, only one high spectral peak at 27 m.y. is apparent, but when the phase is fixed at the present, the highest peak shifts to 28 m.y., with smaller peaks at 32 and 35 m. y. The three most severe mass extinctions (Late Ordovician, ~435 Myr; Late Permian, ~250 Myr; and Late Cretaceous, 65 Myr) are separated by ~180 m.y.

A number of studies found evidence for a possible 28 to 32 m.y. period in impact crater ages. A best-fitting period of 36±2 m.y. is dominant when only the nine largest well-dated craters are used. The differences in the formal periods derived from analyses of extinctions and cratering might at first seem problematic. However, several studies have concluded that the observed differences in the formal periodicity are to be expected, taking into consideration problems in dating and the likelihood that both records would be mixtures of periodic and random events.

Rampino and Stothers proposed a model in which the periodic or quasi-periodic extinction events were related to comet showers caused by the periodic passage of the solar system through the central plane of the Milky Way Galaxy. (The name Shiva Hypothesis was later applied to the galactic comet shower hypothesis in reference to the Hindu deity of cyclical destruction and renewal.) They suggested that the probability of encounters with molecular clouds that could perturb the Oort comet cloud and cause comet showers is modulated by the Sun's oscillation about the galactic disk. Tidal forces produced by the overall gravitational field of the Galaxy can also cause perturbations of cometary orbits. Since these forces vary with the changing position of the solar system in the Galaxy, they provide a mechanism for the periodic variation in the flux of Oort cloud comets into the inner solar system. The cycle time and degree of modulation also depend critically on the mass distribution in the galactic disk.

The time between plane crossings (the half-period of vertical oscillations) is given by:

$$P_{1/2} = (\pi/4G\rho)^{1/2}$$

Where ρ is the mean volume density of matter near the galactic plane. Stothers estimates a total of ~0.15 $M_o pc^{-3}$, and since the density of the known visible matter in the plane is only ~0.10 $M_o pc^{-3}$, the result implies ~30% dark matter (probably cold interstellar clouds). This gives a half-period of 34±3 m.y.; more extreme estimates of dark matter lead to half-periods as short as 27 to 28 m.y. The solar system also undergoes a revolution cycle with a period of ~170±10 m.y., from perigalactic to apo galactic position, and this cycle might also modulate the flux of Oort cloud comets.

Discovery and accurate age-dating of large impact craters, and better determination of the dark-matter component of galactic disk mass should help to clarify and refine both the expected astronomical cycle times and the periodicities detectable in the geologic record. The results could be a new synthesis of astrophysics and the earth sciences.