The Uncertain Nature of Cometary Motions

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The number of active short and long-periodic comets crossing the Earth's orbit each year is less than 10 percent of the corresponding number of asteroids crossing the Earth's orbit. However, the higher relative velocities of comets with respect to the Earth and the uncertainties associated with accurately computing their future trajectories can cause considerable problems when assessing the risks of Earth crossing objects. Unlike asteroids, the motions of active comets are often affected by so-called nongravitational (outgassing) forces that are imperfectly modeled. In addition, the astrometric optical observations that are used to refine a comet's orbit arc often imprecise because a comet's center of mass can be hidden by atmospheric gas and dust. For long-period comets, there is the additional problem of having to base orbital solutions on relatively short observational data intervals.

Long term numerical integrations extending two centuries into the future have been carried out to investigate upcoming Earth close approaches by known periodic comets. Error analyses and impact probabilities have been computed for those comets that will pass closest to the Earth. Although there are no known comets that will make dangerously close Earth approaches in the next two centuries, there area few objects that warrant future monitoring.

Because the cometary atmosphere prevents precision astrometric data and cometary nongravitational forces are imperfectly modeled, the uncertainty in the future motion of an active short-periodic comet is substantially larger than the corresponding uncertainty for an asteroid with a comparable observational history. In addition, comets can split, enter into temporary orbits about Jupiter, and collide with the sun, Jupiter or any of the other planets, including Earth. Using comets such as Swift-Tuttle, Finlay, and Comet Shoemaker-Levy 9 as examples, the problems associated with cometary orbital dynamics and close approaches will be demonstrated,