

Warning Time for Long-Period Comets on Earth Impact Trajectories

P.W.Chodas (Jet Propulsion Laboratory/ Caltech, USA)

The recent close Earth approach of comet 1996132 Hyakutake reminds us of the collision hazard posed by long-period comets, which typically are discovered only a few months to a year or so before they approach the Earth's orbit. These comets have high orbital eccentricities, and encounter the Earth at high relative velocities (e.g. 57 km s^{-1} for comet Hyakutake). These factors combine to shorten the impact warning time should a long period comet be found on an Earth collision trajectory. As a case study, we consider the evolution of the impact probability y for comet Hyakutake, if it had been on such a trajectory. The comet's orbital elements were changed slightly to move its minimum distance from the center of the Earth on March 25, 1996 from 0.1017 AU to 0.00002 AU (Earth's radius being 0.00004 AU). The same observations as C/Hyakutake's were used, with discovery on January 30, 1996, and two pre-discovery measurements on January 1. The observations were adjusted to account for the slightly different trajectory, but included the same set of measurement errors as those in the Hyakutake observation set. The measurement noise value was set at 1 arcsec. The computation of orbit solutions was simulated for various dates, from two days after discovery to a week before impact, and the computed impact probability y and close approach distance versus solution time was plotted. Systematic measurement errors caused the early solutions to be biased away from the Earth. Two days after discovery, with a total of 27 observations, the predicted closest approach was at about two lunar distances, and the probability of impact was only 0.004%. A week after discovery, the predicted close approach distance had fallen to 10 Earth radii, and the impact probability had risen to 1.5%. Two weeks after discovery, the probability of impact was still less than 5%, and the close approach error ellipse was still several Earth radii long, even though over 200 observations had been made. Not until four weeks after discovery, or one month before impact, did the predicted close approach distance fall below one Earth radius. The use of more precise star catalogs, such as the Tycho catalog, would have led to more accurate predictions, with a high impact probability arising significantly sooner.