DETECTION OF METEOROIDS ENTERING THE EARTH'S ATMOSPHERE

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Meteoroids strike the Earth regularly, as can be observed almost every night and sometimes in the day time from the incandescent trail as the meteoroid converts its kinetic energy into radiant energy. In the past, meteoroid impacts have had drastic effects on the geology, climate and ecology of the Earth, and this will surely occur again in the future. In addition to the disaster potential these objects pose, they are of significant scientific interest. The impacting meteoroids are representative of the population of near-Earth objects. The size, orbit and composition distributions of these objects are indicators of the present state and past evolution of the Solar System as a whole and planetary and satellite surface evolution. The impact process is one of the major processes altering surfaces and atmospheres in the Solar System.

The statistical nature of the impacting objects is uncertain to more than an order of magnitude. Although impacts into the atmosphere are observed regularly by eye, no routine and worldwide monitoring system has been available to the scientific community. Some early experiments were conducted from the ground, such as the Prairie Network, which had limited spatial coverage. Defense Department sensors have the capability of providing this near-global and continuous monitoring system to detect and characterize the impacting objects, but these data have been unavailable to the civil scientific community (and sometimes were discarded) because of very real National security considerations. Recently, there has been a National policy change directed at increasing the accessibility of important and relevant data derived from National Defense and Intelligence sensors for civilian applications, including for science and basic research.

As an experiment and demonstration project, these authors have been analyzing data from impact events recorded by some of the available sensors and deriving meaningful and quantitative information and data products which can be declassified and presented to the scientific community. This effort has resulted in the release of the analysis of one large event occurring over the Central Pacific Ocean on February 1, 1994 [1]. Data from other events are also being analyzed and information leading to a statistical analysis of incoming natural objects seems available.

Radiant energy released by the February 1, 1994, event was observed by infrared and visible wavelength sensors on board platforms operated by the U.S. Department of Defense. The object was observed to enter at 24 km/sec on a heading of 300 degrees and at an angle of about 45 degrees. It broke up into several fragments and created debris clouds at 34 km and 21 km. The total kinetic energy of the incoming meteoroid was calculated to be between 1.4×10^{14} to 2.6×10^{15} joules, or 34 to 630 kilotons of TNT. Assuming a density of 3.5 g/cm^3, we derive a mass range of 5×10^5 to 9×10^6 kg and a diameter range of 6 to 17 m. The density could have been considerable less, considering the altitude of breakup, implying a larger object. The orbit just before entry was calculated to be prograde and to have a semimajor axis of about 1.6 AU and an eccentricity of about 0.65, which is an Earth-crossing orbit (see Figure 1).

Data exists for over 60 other events and new events are recorded regularly. We are conducting an ongoing program to analyze and report the analysis of these data with the goal of establishing a statistical description of the near-Earth population of objects in the size range likely to impact the Earth over a decade time scale and with sufficient energy release to be observed during the reentry period. The results of the February 1, 1994 object analysis and our progress with the follow-on effort will be reported.

References:

1. McCord T.B. et al. (1995), Detection of a meteoroid entry into the Earth's atmosphere on February 1, 1994, *JGR-Planets*, in press.

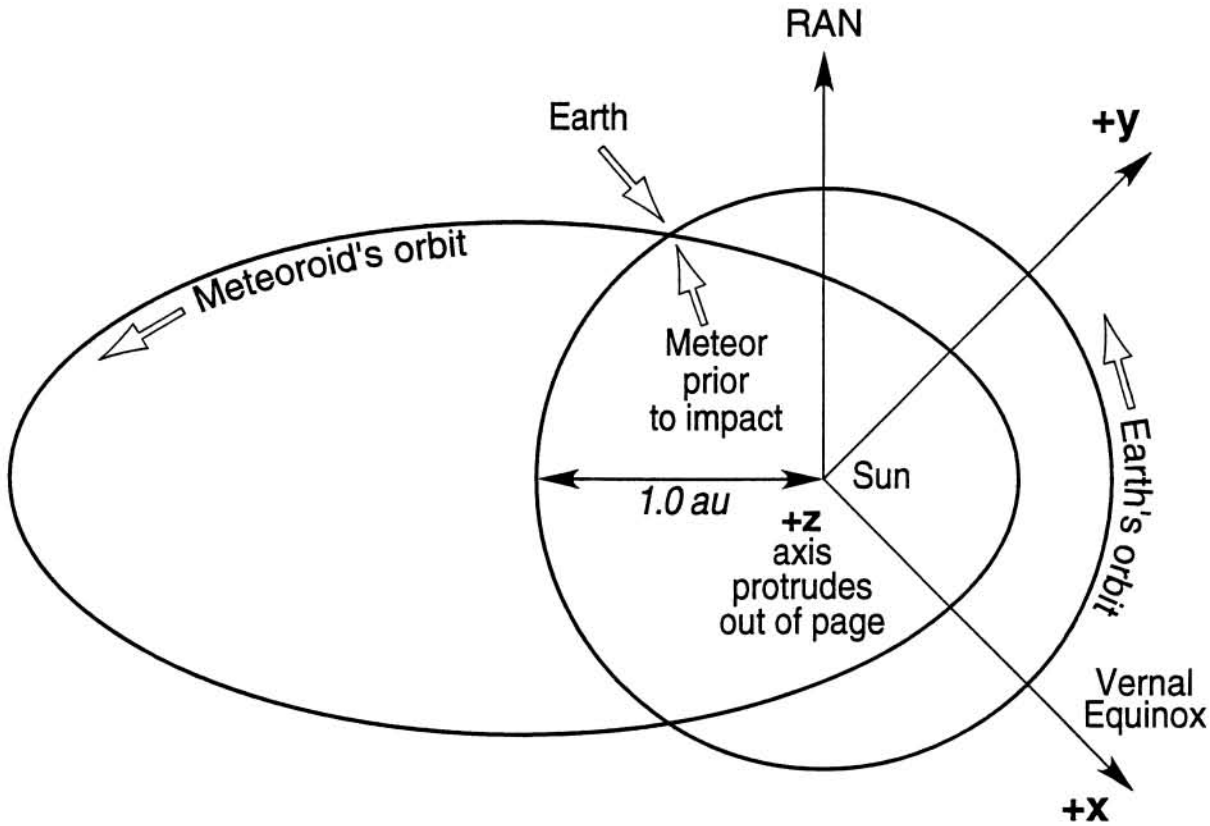

Figure 1: The orbit calculated for the meteoroid just before entry is shown here. This calculation includes effects of atmospheric drag and the Earth's rotation. The orbit plane is inclined to the plane of the ecliptic by 2.1 degrees.