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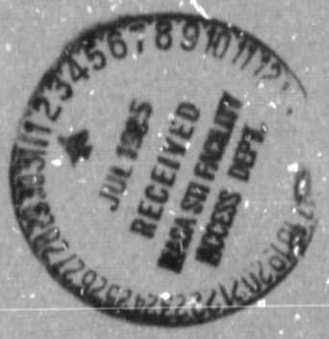
THE STUDY OF THE PHYSICS OF COMETARY NUCLEI

GRANT NSG-7082

Semiannual Progress Reports Nos. 20 and 21

For the period 1 April 1984 through 31 March 1985

Principal Investigator
Dr. Fred L. Whipple



June 1985

Prepared for
National Aeronautics and Space Administration
Washington, D.C. 20546

Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts 02138

The Smithsonian Astrophysical Observatory
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Double Comets, the Opik-Oort Cloud and Asteroid Companions

The early research on Comet P/Holmes (now published in Icarus) suggested strongly that two huge and unique outbursts in 1892-3 resulted from the collisional demise of a small satellite comet. One remaining question concerns the orbital stability of such a companion comet against separation by solar perturbations, assuming that differential non-gravitational forces were finally responsible for the encounter. The problem is not solved in the classical three-body problem of celestial mechanics because the orbit of the secondary mass center, the comet, is moving in a highly eccentric orbit about the Sun, not in the circular orbit assumed classically. Thus computer simulations are required to determine the stability. The major effort has been to develop and utilize an optimized computer program to analyze this problem by repeated calculations.

The stability of comets in the Opik-Oort Cloud about the Sun (and of the proposed companion star "Nemesis") against perturbations by the Galactic center involve the same basic type of calculation. Here again, the supposed persistence of these bodies in orbits over the life of the solar system, depends upon the stability of bodies of negligible mass in orbits around a body whose mass is small compared to the central mass about which they revolve. Although this problem has a limited solution in the classical three-body problem, there remains the question of preferential orientation of extremely eccentric comet orbits, possibly to explain the asymmetry observed among "new" comet motions.

A third application of the computing programs is suited to meteoroids that may exist in orbits about asteroids and that may endanger science spacecraft making flybys too near to asteroids. As in the double-comet case, solar activity

(radiation and solar wind) in addition to solar gravitational perturbations limit the extent to which an asteroid may be attended by small meteoroids in orbits about it. Preliminary calculations suggest that the miss distances now planned for asteroid fly-bys are adequate.

Progress in choosing and coding efficient programs for these calculations is well underway along with preliminary calculations.

Other Activities

An extensive amount of literature study has been made by Whipple with regards to the many proposals concerning the paleontological record of biological extinctions, impacts of comets on the Earth, impact craters on the Earth, the Sun's motion across the galactic plane, "Nemesis" as a possible companion star to the Sun, and related quasi-periodic phenomena on astronomical time scales. He aided in the planning of the related conference "The Galaxy and the Solar System" held at Tuscon in January 1985.

His current opinions on these subjects based on extensive research by a number of authors are:

1) Motion of the Sun and Solar System above and below the galactic plane is unlikely to have produced any quasi-periodic effects of comet showers on the Earth.

2) Quasi-periods in the range of 26 to 33 million years in biota extinctions, impact cratering on the Earth or other paleontological or geological effects remain highly uncertain and may be subjective.

3) The Cretaceous-Tertiary mass extinction 65-million years ago was almost certainly caused by the impact of a small asteriodal-type body of diameter the order of 10 kilometers although the major physical effects of such an impact

are still to be thoroughly explored.

4) Postulated comet showers caused by Nemesis (or whatever) appear to be highly unlikely causes of the postulated quasi-periodic extinction phenemona because so few comets appear to be massive enough to produce the events.

5) More research is needed to clarify with much assurance the persistence of the Öpik-Oort Cloud and place of origin of comets.

6) A major question still remains as to whether comets contribute significally to the Apollo and Amor asteroid population.

7) Whipple has been active in consulting with the U.S. National Academy of Science's Committee on Planetary and Lunar Exploration (COMPLEX) and two of NASA's committees: the Comet Rendezvous Science Working Group and the International Halley Watch. The approach of Halley's comet has involved an increasingly time-consuming contact with possible observers, the media and planetariums.

PUBLICATIONS

1984 Present Status of the Icy Conglomerate Model. (Center for Astrophysics Preprint Series No. 1966). Invited paper presented at NATO Advanced Research Workshop on "Ices in the Solar System". Nice. France, January 1984.

1984 COMET P/HOLMES, 1892III-A CASE OF DUPLICITY? (Center for Astrophysics Preprint Series No. 1995, April 1984. To appear in ICARUS, Vol. 60, No. 3, December 1984.