SOME PROBLEMS IN THE THEORY OF COMETS, I

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1. Introduction

This paper is concerned with the integral equations which arise in *any* theory of comets when account is taken of the perturbation in energy state which occurs at each penetration of and passage through the planetary zone. The comet can be thought of as executing a random walk along the scale of energy states, where we define the energy state of a comet as the negative of its total energy per unit mass (so that the energy state is zero when the comet is at rest "at infinity"). It will be convenient to measure the energy state z by the reciprocal $1/a$ of the semimajor axis of the instantaneous orbit, in a.u.$^{-1}$ (so that $z = 1$ for the earth). For a parabolic comet $z = 0$, and when $z < 0$, as is sometimes the case at perihelion, it will mean that a particle having the comet's position and velocity would, if not further perturbed, leave the solar system on a hyperbolic orbit. However, the ultimate fate of a comet is not entirely determined by its instantaneous orbit at perihelion; a further passage through the planetary zone must take place before it will be even approximately correct to think of the comet as moving in a pure inverse-square field, and elaborate perturbation calculations are necessary before what I shall call the *postorbit* (the orbit after emerging from the planetary zone) can be determined. Similar calculations directed backward in time enable the *preorbit* to be found (this is the orbit before entry into the planetary zone). Some 24 preorbits have been calculated by E. Strömgren [17] and others, and recently I. V. Galibina [4] (employing a new method due to S. G. Makover [10]) has calculated 20 postorbits; practically all the comets studied in this way had hyperbolic or at least near-parabolic orbits at perihelion. Two decisive results have emerged from this work:

(1) *the observations are consistent with the statement that hyperbolic preorbits do not exist;*

(2) *some (perhaps about 15 per cent) of the comets having parabolic perihelion orbits leave the solar system on hyperbolic postorbits.*

This estimate is based on the fact that the energy state in the postorbit minus that in the perihelion orbit is found to be distributed about a mean value of about $+0.000\,50$ with a standard deviation of about $0.000\,50$.