ROTATION PERIODS OF HALLEY'S AND OTHER COMETS

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Rotation periods are fundamental physical properties of comets, providing information about the strength of cometary nuclei and possible relations to Earth-approaching asteroids, as well as being necessary to interpret other measurements of physical properties, such as Halley's CN spiral jets[1]. The plethora of observations from spacecraft and the ground of Halley's comet has generated a heated debate on the rotation period of this best-observed of all comets. There is good evidence for periods of both 2.2 days (53 hr) and 7.4 d (178 hr). Campbell[2] and Kerr[3] provide summaries of the data supporting each period, as well as insights into the sociology of a chaotic but rapidly evolving period of scientific discovery. In order to reconcile these apparently valid but conflicting observations J. Lissauer proposed that the comet rotates in 2.2 d but nutates (or wobbles) about its rotation axis every 7.4 d (reported by Kerr). The reverse - a rotation about the long axis every 7.4 d with a 2.2 d nutation - is suggested by Sekanina (submitted).

A characteristic of all of the ongoing discussions is their concern solely with Halley's comet. I propose that rotation periods and other features of all studied comets may help put the conflicting periodicities for Halley in perspective. Comet data used are extracted from an unpublished database of cometary physical and orbital characteristics complied for just such comparative and statistical studies[4]. Nearly all rotation periods tabulated in the database were derived by Whipple[5], based upon analyses of expanding halos assumed to be given off by a single icy spot on each rotating nucleus. The existence of at least two major jets emanating from Halley during its 1986 apparition warns that the assumption may not always be met, and in fact, probably explains the incorrect rotation period (10 hr) deduced for Halley using Whipple's method. However, Whipple's results are generally in agreement with the few determinations made by other methods.

The average rotation period of 46 comets analysed by Whipple[5] is 15 hr, ranging from 4.1 and 120 hr (Fig. 1). A rotation period of 53 hr is not exceptional - 6 other comets rotate slower, 40 faster. The proposed rotation period of 178 hr for Halley is considerably slower than for any other comet , and thus must be considered less likely.

A second way to evaluate the conflicting rotation periods is to compare them with a statistical relationship between rotation period and another quantity. The only such relation that appears possibly significant links rotation period and nuclear radius (Fig. 2). The latter quantity is also known only poorly, usually being based on measures of comet brightness and assumptions of nuclear albedo (e.g. ref. 6). But, as Kresak[7] found, such estimates of size correlate well with the greatest heliocentric distance at which comets are visible, which must depend largely on size for any reasonable albedo values. The main uncertainty in radii determinations is the albedo of the nucleus; Halley's dark nucleus suggests that some comets are probably larger than previously estimated.

Comet rotation periods decrease with increasing nuclear radius; small comets rotate rapidly, large ones slowly (Fig. 2). This is consistent with Whipple's[5] finding that rotation periods are inversely related to brightness. One possible interpretation of Figure 2 is that relatively new comets are large and rotate slowly. As they evolve by repeated excursions through the inner solar system they become smaller by loss of volatiles and dust when near the sun and by occasional impact cratering events. Collisions and/or jetting of material from the nucleus may also spin up the comet.

Independently of its interpretation, Figure 2 can be used to predict how rapidly a comet of known radius is spinning. Using Halley's radii of 4 by 8 km yields rotation periods of 34 to 54 hr; 178 hr is completely inconsistent with the data from other comets.

These statistical comparisons do not identify which is the "real" rotation period of Halley, but rather indicate that the shorter period is most compatible with whatever phenomena is measured using Whipple's expanding halo technique. The existence of 2 apparently real periodicities for Halley is undoubtedly due to its irregular and elongated shape and perhaps to its multiple active regions. A nearly spherical comet nucleus would not nutate significantly, and any periodic behavior would thus represent rotation alone. Is Halley, which is unique in so many ways[8], also an oddball in terms of its shape and rotation?

References: (1) A'Hearn, M.F. et al., *Nature 324*, 649 (1986). (2) Campbell, P., *Nature 324*, 213 (1986). (3) Kerr, R.A., *Science 234*, 1196 (1986). (4) Wood, C.A., Reports of Planetary Geology Program, 1985 (in press). (5) Whipple, F.L., in *Comets* (ed. by L.L. Wilkening) Univ. of Arizona Press, Tucson, 227 (1982). (6) Spinrad, H. et al., *Publ. Astron. Soc. Pacific 91*, 707 (1979). (7) Kresak, L., *Bull. Astron.* Czech. 25, 87 (1974).

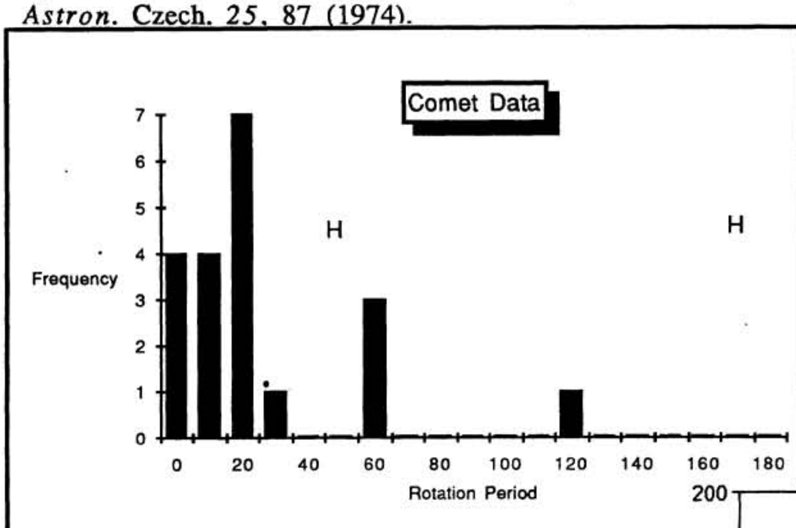

Fig. 1: Distribution of rotation of 46 comets as determined by Whipple[5]. Hs represent 2 proposed rotation periods of 53 and 178 hr for Halley's comet.

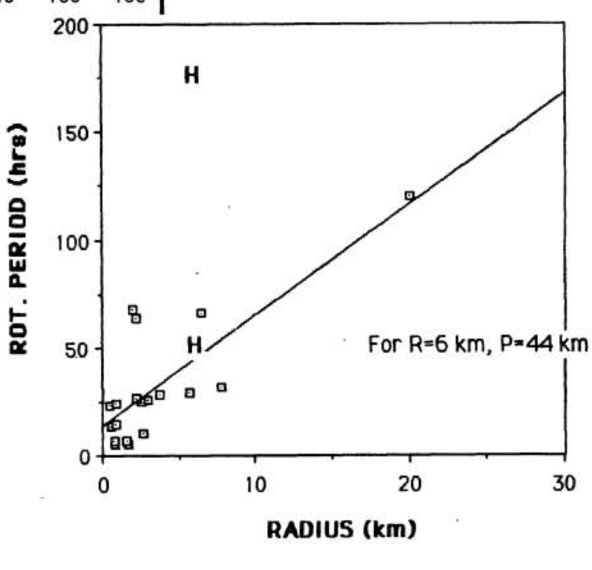

Fig. 2: Relation between comet rotation period and nuclear radius. Hs represent proposed rotation periods of 53 and 178 hr for Halley's comet.