Astronomy

What is at the centre of Halley's comet and how fast does it spin?

from David W. Hughes

THE source of all the gas and dust emitted by Halley's comet as it speeds past the Sun is thought to be a compact, dirty snowball nucleus. Compact because the comet's mass of 2×10^{17} g is confined in an object of mean diameter 9.4 km. Dirty because around 25 percent of the mass is made up of silicate particles weighing between 10^{-15} and 10 g, with a composition similar to carbonaceous chondrite meteorites, and probably evenly mixed with what is predominantly H_2O snow. At its last apparition in 1910, the comet lost about 2×10^{14} g of material, equivalent to peeling a layer 200 cm thick from the surface of the nucleus. Observations of Halley's comet over the past 2,000 years are consistent with the same rate of surface loss at each apparition. But what does the nucleus look like? And how fast is it spinning?

At this approach to the Sun, the comet was first seen on 16 October 1982 when it was 11.04 AU away. It is in opposition (on the opposite side of the Earth to the Sun) around January and during that time observers have been carefully monitoring its brightness. Two papers detailing last year's results have been published in a recent edition of *Astronomy and Astrophysics*. One group (Le Fevre, O. *et al. Astron. Astrophys.* **138**, L1; 1984) used the 3.6 m Canada-France-Hawaii telescope. The other (West, R.M. & Pedersen, H. *Astron. Astrophys.* **138**, L9; 1984) used the 1.5 m European Southern Observatory telescope at La Silla, Chile. Both found that the brightness of the comet is changing not only because of the slow variation in heliocentric and geocentric distances but also throughout the night and from night to night.

An analysis of the comet's absolute magnitude (magnitude reduced to the idealized position where the comet is 1 AU from both the Sun and Earth and seen at full phase) shows that this quantity did not change perceptibly between October 1982 and March 1984. During this time the heliocentric distance of the comet decreased from 11.05 AU to 7.75 AU, and the insolation went up by a factor of two. So it is reasonable to suppose that the cometary snow was not sublimating, dust was not being accelerated away from the nucleus and the comet was inactive. This conclusion is supported by the fact that the comet image was perfectly round and very similar to the telescope's seeing disc.

Magnitude can be measured to ± 0.2. West and Pedersen found that the night-to-night variation had an amplitude of 1 magnitude (equivalent to a brightness change of 2.5), and Le Fevre *et al.* found an amplitude of about 1.7 magnitudes (equivalent to a brightness change of 4.8). Two explanations, both relying on the spin of the nucleus, have been put forward to explain this variation.

The first assumes that the surface of the nucleus has a uniform albedo and that the nucleus is not spherical but elongated. A lemon-shaped object, spinning about its axis of maximum moment of inertia (this axis being perpendicular to the plane of its orbit), would give the observed brightness readings if the long axis was about 1.9 times larger than the short axis. The brightness is simply proportional to the area of cross section presented to the observer. One problem with this hypothesis is that asymmetrical outgassing when the nucleus is close to perihelion would induce a precession of the spin axis, whereas orbital analysis indicates that the two non-gravitational parameters have remained reasonably constant over the past 2,000 years showing that the precession rate must be low.

The second possibility is that the nucleus is nearly spherical but the reflectivity varies over the surface. Maybe it is like Saturn's satellite, Iapetus. This has a synchronous spin period (always presenting the same face to Saturn) but, as it orbits the planet the leading face is dark (albedo ~ 0.045), whereas the trailing face is much brighter (albedo 0.5). The spin axis is near the plane of separation of the two hemispheres. Notice that the brightness of the nucleus would be proportional to the mean albedo of the surface facing the observer. One hemisphere could be covered with friable carbonaceous dust with a lunar-like albedo of 0.07, the other could be characterized by exposed areas of ice with an albedo of 0.6. But how is such an asymmetrical and inhomogeneous nucleus produced? And how could this lack of symmetry persist after many millions of rotations and the 2,300 or so close solar passages that Halley's comet has already endured? There again, complicated jet and fan-like structures have been seen in the inner comas of comets. These could arise from active zones on the rotating nucleus producing a burst of gas and dust as they are heated by being spun through the subsolar point.

Returning to Halley's comet, what is the spin period of the nucleus? Whipple (*IAU Circular 3459*, 13 March 1980) analysed photographs and drawings of the 1910 and 1835 apparitions, paying special attention to the evolution of selected dust-ejection features, and tentatively set a 10.3 h spin period. Sekanina and Larson (*Astron. J.* in the press) returned to the problem and concluded that the period was about 41.5 h. LeFevre *et al.* suggest that their data can be fitted by a period of 48-51 h but stress that, if the brightness variation is sinusoidal, a period of 24.3 ± 0.3 h is also very likely and that submultiples (of approximately 12.2 h and 8.1 h) may also agree with the observations.

This confusion is not helped by the fact that an observer based at a single observatory on the spinning Earth can only see the comet for about 3 hours out of 24. Has the problem been solved by a collusion of observers in Chile, South Africa and Australia? By December 1984, the comet was within 5.5 AU of the Sun, the snow was starting to sublimate and the cometary nucleus had become shrouded from view by the brighter surrounding coma. If the relevant data have not been collected, the measurement of the spin period of the nucleus will have to wait for the GIOTTO spacecraft to fly by the comet in March 1986 or until the coma has dissipated as the comet moves away from the Sun into the deep freeze at the boundaries of the solar system. □

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Neuroscience

Skeleton key to memory?

from N. R. Burns

COUNTERPARTS to the proteins that form the skeleton on the inner surface of the membrane of the red cell have been found in many other cell types (see ref. 1), in which they are presumed to stabilize the membrane. But searches have also been made for a more dynamic function of the membrane skeleton, for example in the transduction of signals from plasma membrane receptors to the interior of the cell. The latest and most dramatic claim, however, which emanates from G. Lynch and his co-workers, is that the skeleton has a function in the mechanism of memory.

When certain synapses in the rodent hippocampus are subjected to brief, high-frequency stimulation, the postsynaptic potentials evoked by subsequent stimulation are significantly increased. This is referred to as long term potentiation (LTP). It may last for days and has been considered a possible model for the basic synaptic changes that underlie learning and memory. Lynch and his colleagues have