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PREDICTED FAVORABLE VISIBILITY CONDITIONS FOR ANOMALOUS TAILS OF COMETS

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It was shown elsewhere (Sekanina, 1974) that the observability from the earth of an anomalous tail (antitail) of a comet can be rather straightforwardly predicted from the dynamical and geometric conditions. The physical presence or absence of the antitail at a precalculated time is then a measure of the comet's production rate, at the relevant emission times, of relatively heavy dust particles (mostly of submillimeter size) that constitute such an antitail. Because the large grains are emitted from the nucleus at very low velocities (typically meters or tens of meters per second), an antitail is essentially a two-dimensional formation in the orbit plane of the comet and can be recognized best when projected edge-on, i.e., when the earth crosses the nodal line of the comet's orbit. In general, however, this condition is not essential for the recognition of antitails (cf., e.g., Comet Kohoutek 1973 XII).

Since the emission rate of heavy dust particles is a potentially significant parameter for a physical classification of comets, we made use of the visibility conditions to list the comets that should have displayed a sunward tail around the time of the earth's passages through the orbit plane. This type of the antitail observability will be termed the nodal appearance. A computer program executing the conditions for a nodal appearance was applied to the Catalogue of Cometary Orbits (Marsden, 1975), starting with the comets of 1737. However, we excluded all comets that were at the critical times located near the antisolar point in the sky (elongations exceeding 135°), where the definition of the sunward direction becomes meaningless. We also excluded all cases at heliocentric distances larger than 2 AU in order not to confuse the antitails with the icy tails (Sekanina, 1973, 1975) that are observed far from the sun and point fairly frequently in the general direction of the sun.

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The statistics of the nodal appearances of antitails of comets, whose conditions were satisfied within, or not more than 5 days outside, the period of observation, are listed in Table I, separately for nearly-parabolic comets (revolution periods more than 200 years) and for short-period comets. The calculations were done for dust particles with a ratio 1-μ of radiation pressure to solar gravity of 0.01 (known to be common in observed antitails) and for two different starting emission times. Whereas the choice of 1-μ is not crucial, Table I shows that the time of onset of dust production affects the statistics substantially. The comets with a sunward tail reported to have been detected near the predicted time are listed in Table II, where columns 2 to 4 give, respectively, the perihelion distance, the reciprocal value of the original semimajor axis (for P/Encke the revolution period), derived from Marsden (1975) and from Everhart and Raghavan (1970), and the absolute magnitude (Vsekhsvyatsky, 1958). We remark that with the exception of 1937 IV the comets have perihelia well inside the earth's orbit, and that apart from the controversial case of P/Encke (see details below) the comets' revolution periods are longer than 7000 years and their absolute magnitudes brighter than 8.

Table I points consistently to a conclusion that only about 20 to 30% of the nearly-parabolic comets that should have displayed an antitail at the node were actually observed to do so. Indeed, if we count only the comets with nearly-ideal observing conditions, the figure is 22% for the onset of emission at 4 AU and increases to 30%, if the condition is relaxed to 2 AU. If we count all comets that were observed near the node, the fraction of positive observations is lower, as can be expected, but not very substantially: we find 19% for 4 AU emissions and 23% for 2 AU emissions.

The results are dramatically different for short-period comets. Although there were numerous opportunities for observing a nodal appearance of an antitail, we do not yet have a single clearly positive observation. The only promising case so far is that of P/Encke in 1964, for which Roemer (Roemer and Lloyd, 1966) secured a pair of plates only 2.5 days after the earth's nodal passage; the comet was 88 days after perihelion. A close inspection of the plates by Dr. Roemer and the writer revealed two extensions emanating from the weak, nearly stellar image of the comet in the opposite directions, one of them pointing right toward the sun. Although this sunward tail does not, in the writer's opinion, resemble the gas jets, frequently observed in P/Encke before perihelion, there is still no more than a 50% chance that it is a true antitail.

Table I. Statistics of predicted nodal appearances of antitails of comets in the past ($1-\mu = 0.01$)

Comets	Nearly-parabolic		Short-period	
Assumed sun-comet distance at ejection (before/at perihelion)	4 AU	2 AU	2 AU	Perihelion
(A) Number of comets (apparitions) whose predicted nodal appearances of antitail lie within the observed arc of orbit	69	45	21 (32)	6 (7)
(B) Number of comets (apparitions) under (A) that were observed near the node	48	30	16 (23)	6 (7)
(C) Number of comets (apparitions) under (B) with significant predicted characteristic length of antitail	38	28	15 (20)	2 (2)
(D) Number of comets (apparitions) under (C) with elongations exceeding 30° from the sun at the node	30	20	15 (19)	2 (2)
(E) Number of comets (apparitions) under (D) that were free from severe moonlight interference at the node	18	10	7 (10)	2 (2)
(F) Number of comets (apparitions) under (B) whose antitail was actually observed	9	7	1?(1)?	1?(1)?
(G) Number of comets (apparitions) under (E) whose antitail was actually observed	4	3	1?(1)?	1?(1)?

Table II. Comets with antitails observed at node

Comet	q (AU)	$(1/a)_{orig}$ $(AU)^{-1}$	H_{10} (mag)	Date of node crossing	Antitail seen	Conditions at node and remarks
1823	0.23	.	4.2	1824/1/24	1/22-25, 27, 31	Very favorable conditions
1844 II	0.86	+0.001007	4.9	1844/10/25	11/3, 8	Close to sun; moonlight interfering
1844 III	0.25	+0.002592	4.9	1845/1/18	1/11, 16, 25, 27	Moonlight interfering
1895 IV	0.19	-0.000168	5.2	1896/2/9	2/15, 19-21	Close to sun
1937 IV	1.73	+0.000063	6.0	1937/7/31	7/30, 8/1	Favorable; but early emissions only
1954 VIII	0.68	+0.000051	7.0	1954/7/25	7/30, 8/1, 3, 6-7	Node crossed 3 days before discovery
1957 III	0.32	+0.000009	5.4	1957/4/25	4/22-30	Very favorable conditions
1961 V	0.04	+0.002211	7.5	1961/7/21	7/25-26, 8/1	Node crossed 2 days before discovery; close to sun; moonlight interfering
1964 IV	0.34	(3.30 yr)	13-15	1964/8/27	8/30	P/Encke; nature of tail not clear
1969 IX	0.47	+0.000507	5.8	1970/1/2	12/26-28, 30-31, 1/2	Antitail short; early emissions only

The general absence of antitails among the short-period comets appears to be incompatible with the existence of meteor streams known to be associated with many of these comets. Unfortunately, at their observed returns, the parent comets of the three spectacular-storm producing meteor streams — P/Biela, P/Giacobini-Zinner and P/Tempel-Tuttle — were never placed favorably enough for a nodal appearance of an antitail. And, of all the other comets known to be related to meteor streams, only two had such very favorable apparitions: P/Encke in 1878, 1888 and 1964, and P/Pons-Winnecke in 1909, although P/Pons-Winnecke is not apparently associated with a permanent stream (Cook, 1973). The other comets with favorable conditions were P/Tempel 1 in 1867, P/Finlay in 1919, P/Kopff in 1945, P/Grigg-Skjellerup in 1947, and P/Schaumasse in 1952 and 1960. Streams that could be associated with P/Finlay or P/Grigg-Skjellerup have never been reported; the other comets have perihelia well beyond 1 AU.

With one doubtful and two negative results in the three nearly-ideal returns, P/Encke presents probably the most solid evidence to date against the positive correlation between the antitails and the meteor streams. In order to obtain more data, positive or negative, on the occurrence of the antitails, we investigated their visibility conditions in the future returns of the short-period comets. Among 166 returns of 60 comets with perihelia within 2 AU between 1976 and 1999 (orbital elements courtesy of Dr. Marsden), the following instances — most of them outside nodal areas — are considered as most significant: P/d'Arrest in 1976/77, P/Encke in 1977 and 1987, P/Schwassmann-Wachmann 3 in 1979, P/Honda-Mrkos-Pajdušáková in 1980, P/Grigg-Skjellerup in 1982 and 1987, P/Crommelin in 1984, P/Pons-Winnecke in 1989/90, and P/Giacobini-Zinner in 1999.

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