η LYRID METEOR STREAM ASSOCIATED WITH COMET IRAS-ARAKI-ALCOCK, 1983 VII

K. Ohtsuka
Tokyo Meteor Network
1-27-5 Daisawa, Setagaya-ku,
Tokyo 155, JAPAN

ABSTRACT. The probable association of Comet IRAS-Araki-Alcock with the η Lyrid meteor stream is suggested, and the possible relation of the radio meteor shower on 1983 May 10 is also discussed.

1. INTRODUCTION

Long-period Comet IRAS-Araki-Alcock 1983VII (hereafter, IAA) has closely encountered with the Earth up to the distance of 0.03 AU, and has passed through the descending node, of which distance to the Earth's orbit is 0.006 AU, in May 1983. Drummond (1983a) predicted an apparition of meteor shower associated with IAA on May 10.1 UT, 1983, and several meteor observations were carried out around the theoretical maximum.

The orbital elements of IAA are given in "Catalogue of cometary orbits" (Marsden 1989). The original, osculating and future reciprocal semimajor axes are +0.010466, +0.009972 and +0.010572, respectively. This means that IAA has been belonging to the solar system, revolving around the Sun at least two times with a period of $\approx$1000 yr. The periodicity of IAA may be also supported by some physical properties found from ultraviolet, optical and infrared observations (e.g. Festou 1983; Hanner et al. 1985; Festou et al. 1987; Watanabe 1987). These facts suggest that an associated meteor stream will be formed along the cometary orbit.

2. η LYRIDS: PHOTOGRAPHIC METEORS ASSOCIATED WITH IAA

In the present work, five meteors probably associated with IAA are selected out among some 5800 orbits in the published photographic meteor catalogues. For comparing the date, radiant and orbital elements of individual meteors with those of IAA, the D-criteria were applied, as listed in Table 1. D_{SH} and D' denote the D-criterion of Southworth and Hawkins (1963), and of Drummond (1981), respectively. The orbital elements of IAA computed by Marsden (1989), and the theoretical IAA meteor radiant computed by Hasegawa (1990), are also given in Table 1.

It should be noted in Table 1 that the orbital elements of IAA and

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Table 1. Orbits of photographic η Lyrid (a) meteors and Comet IRAS-Araki-Alcock, 1983VII (equinox B1950.0)

No.	Date 1900+ UT	R.P. α_{1950}	δ	V_G km/s	e	q AU	1/a AU^{-1}	i 1950	ω 1950	Ω 1950	D_{SH}	D′
7598 [1]	53- 5- 9.36	288°	+43°	44.6	1.00	1.00	-0.0043	75°	194°	48°.4	0.039	0.014
203 [2]	61- 5- 9.96	289.2	+42.5	46.1	1.085	0.996	-0.0855	76.6	193.3	48.9	0.112	0.050
12068 [1]	54- 5-10.39	290	+43	46.3	1.12	1.00	-0.1149	77	191	49.1	0.149	0.066
8441 [3]	56- 5-11.42	287.7	+44.7	44.4	1.083	0.996	-0.0840	72.9	193.5	50.6	0.103	0.049
640322 [4]	64- 5-11.77	290.1	+43.3	44.9	1.021	0.998	-0.0209	75.1	193.1	50.9	0.064	0.026
Mean	5-10	289.0	+43.3	45.3	1.062	0.998	-0.0619	75.3	193.0	49.6	0.093	0.041
S.D.		±1.0	±0.8	±0.8	±0.044	±0.002	±0.0421	±1.4	±1.0	±1.0	±0.039	±0.019
1983VII [5]	5- 9	288.0	+44.0	43.8	0.990	0.991	+0.0100	73.2	192.8	48.4	0.006*	

1) McCrosky and Posen (1961). 2) Kramer and Markina (1966). 3) McCrosky and Shao (1969).
4) Babadzhanov et al. (1968). 5) Marsden (1989), a radiant prediction is from Hasegawa (1990).
* minimum distance of orbits between IAA - Earth.

five meteors are considerably similar to each other. Individual D-value is remarkably small in the ranges of $D_{SH} \leqq 0.15$ and $D' \leqq 0.07$; therefore, this ensures the existence of the meteor stream associated with IAA. As a matter of fact, Terentjeva (1968) has already found the same meteor stream: this is Stream No. 203 in her catalogue, designated as η Lyrids, segregated from the three groups of (a), (b) and (c). The five meteors found out in the present work are quite identical with the (a) group of η Lyrids, because Terentjeva gives the mean orbit of two photographic meteors, Nos. 7598 and 12068, which are listed in Table 1. In the present study three photographic members of the η Lyrids (a) are newly discovered. Moreover, two other photographic meteors, of which D-values are in the association range of $D_{SH} \leqq 0.25$ or $D' \leqq 0.105$, are also found out: they are Nos. 11994 and 7686 in the catalogue of McCrosky and Posen (1961). They might be members of the η Lyrids (b) or (c). Although their orbits are somewhat different, they are still possibly associated with IAA judging from the D-criteria.

3. METEOR OBSERVATIONS IN 1983

According to Drummond's (1983a) prediction of the IAA meteor shower on May 10, series of radar, visual and photographic observations were carried out in a few days around May 10 (Millman and Cook 1983; Clifton 1983; Drummond 1983b). However, these observations did not give any positive results upon the shower activity.

On the other hand, Shimoda and Ono (1983) detected enhanced forward-scattering echoes due to an activity of some meteor shower by using FM radio. The shower peaked on May 9.9 UT, and the activity duration was less than two hours. The maximum rate was about 80/hour, which was almost the same scale of η Aquarids. This rate was twice as the background rate at the same time in the previous and following day. The solar longitude $\lambda_{\odot}$ at the maximum corresponds to 48.3°(B1950.0), which was close to the theoretical $\lambda_{\odot}$ of 48.4°; therefore, this shower activity is possibly related with Comet IAA. Nevertheless, the negative result was obtained by the radar observations at Ottawa in the same time (Millman and Cook 1983), which was caused by the situation that radiant point was below or near horizon in that place.

4. DISCUSSION

It is no wonder that the association between a long-period comet and meteors is confirmed. Several cases have ever been reported, e.g. Comet 1861 I ($a \simeq 56$ AU) and Lyrids, Comet 1911 II ($a \simeq 185$ AU) and Aurigids, Comet 1739 (assumed $e = 1$) and Leo Minorids, and recently, Comet 1987 III ($a \simeq 180$ AU) and ε Geminids (Olsson-Steel and Lindblad 1987; Olsson-Steel 1987; Hasegawa 1990), and Comet Mellish 1917 I ($a \simeq 28$ AU) with relatively long period and Monocerotids (Ohtsuka 1988; Lindblad and Olsson-Steel 1990). Therefore, the association between IAA ($a \simeq 100$ AU) and η Lyrids would be an additional example.

The five meteors listed in Table 1 were observed 19-30 yr earlier than the time at the latest periherion passage of IAA, i.e. May 21 ET, 1983. Let us consider when these meteoroids were released from the IAA nucleus. We assume that these were ejected from the nucleus towards anti-IAA motion with a velocity of 1-2 $m \cdot s^{-1}$ near the IAA periherion in the previous return. We neglect the effect of gravitational and non-gravitational perturbations. Assuming the period of IAA as 1000 yr, then, we can obtain the result that these meteoroids should return 15-30 yr preceding to the comet; it is approximately consistent with the meteor observations. According to the radar observation of IAA at Arecibo, it was implied that large particles, of which radius corresponds in the order of 2-3 cm, exist within the dust-cloud around the IAA nucleus. Thier ejection velocity from the nucleus was estimated as 2.7 $m \cdot s^{-1}$ (Harmon et al. 1989). This value is consistent with that of above assumed. If such a large particle will enter into the Earth's atmosphere, the meteor should brighten up to be a fireball, which would be well-observable by using small cameras. Such a bright meteor has actually been observed at Odessa (Kramer and Markina 1966): this is Meteor No. 203 in Table 1. Kramer and Markina reduced the initial mass of meteoroid m_∞ as 14 gram. If the bulk density for the meteoroid is assumed to be ~ 0.5 $g \cdot cm^{-3}$, the radius will be ~ 2 cm. Therefore, some of the five meteoroids may be ejected from the IAA nucleus in the previous return.

Although the orbital eccentricity of IAA is smaller than 1, those of five meteors given in Table 1 are larger than 1. It may be accounted that these hyperbolic orbits were caused by observational errors, especially by poor determinations of the no-atmospheric velocities. Therefore, those hyperbolical characters are far from realistic.

Now we discuss the FM radio meteor shower in May 1983, observed by Shimoda and Ono (1983). Considering the facts that the theoretical and observed $\lambda_\odot$ were close to each other, and that the duration of meteor shower activity was very short, we can judge that the meteoroid particles should be concentrated to the cometary orbital plane. It means that the stream is at early stage in its formation. The elapsed time would have been short since released from the comet. This stream might consist of small particles (mass of $10^{-2} \sim 10^{-4}$ gram) because large echoes due to the visual-size meteoroids could have scarcely been received (Shimoda and Ono 1983). IAA has passed through the descending node on May 12.1, two days later than the Earth, where the distance of orbits between IAA and the Earth is only 0.006 AU, and the difference of mean anomalies between IAA and the FM radio meteors is only 0.002°! In spite of such an excellent condition for a meteor shower production, there was no strong shower. This means that the large-dust cloud near IAA was much sparser than the cases of Leonids and Draconids. This may be connected with the fact that infrared and radar observations for the dust production rate indicate IAA as a dust-poor comet (Hanner et al. 1985; Harmon et al. 1989).

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