THE NEW METEOR SHOWER η ERIDANIDS

K. Ohtsuka[(1)], T. Tanigawa[(2)], H. Murayama[(1)], I. Hasegawa[(3)]

[(1)] Tokyo Meteor Network, 1-27-5 Daisawa, Setagaya-Ku, Tokyo 155-0032, JAPAN
Email: ohtsuka@jb3.so-net.ne.jp
[(2)] Arima High School, 2-1-50 Tenjin, Sanda C., Hyogo 669-1531, JAPAN
[(3)] Otemae University, Faculty of Socio-Culture, Inano, Itami 664-0861, JAPAN

ABSTRACT

We discovered the new meteor shower, η Eridanids, active in late July to mid-August by analyzing the optical meteor data besides the visual and radar ones obtained so far. We also found two comets as parent candidates of the η Eridanids, Periodic Comet Pons-Gambart D/1827M1 and Comet Chacornac C/1852K1; and further, Comet Chacornac, rather than Comet Pons-Gambart, seems to be possibly associated with the η Eridanids.

1. INTRODUCTION

The Tokyo Meteor Network photographic meteor program [1] is still operating, using 35 mm-size cameras equipped with *fl.* 85 ~ 135 mm objective lenses. Approximately 200 double-station meteors have been obtained so far, ~ 10% meteors being the sporadics or the minor shower members. One of such non-major shower meteors was observed on August 12.74 UT, 1994, as a by-product during the 1994 Perseids observation program: a −1 mag. meteor, T9408-05, radiated from near η Eridanus. The orbital parameters were precisely reduced since the error estimates were 0.05° arc and < 1% in the radiant and velocity determinations, respectively. We found subsequently T9408-05 to be a member of the newly discovered meteor shower.

2. DISCOVERY OF THE NEW METEOR SHOWER: η ERIDANIDS

2.1 Optical (Photographic and TV) observations

We often use the D-criteria in investigating the orbital similarity between meteors, or a comet and meteors: e.g., D_{SH} by Southworth and Hawkins [2]; recently proposed D_N and D_R by Valsecchi et al. [3]; etc. We applied here conventional D_{SH} in order to survey whether the same meteor shower members as T9408-05 exist or not, discriminating by D_{SH} (M, N) $\leqq$ 0.15, where D_{SH} (M, N) represents D_{SH} between a mean orbit M of the meteor stream and an individual meteor N, including T9408-05. As a result, interestingly, there were no associated meteors among ~ 6000 orbits in the IAU photographic meteor orbit data obtained up to 1980's [4], while three associated meteors could be selected out from among ~ 2000 more orbits recorded in the optical (photographic and TV) meteor catalogues published later: 2 photographic meteors, EN030895 [5] and DMS93168 [6]; 1 TV meteor, MSSIQN [7]. D_{SH} (M, N) $\leqq$ 0.15 means that each individual meteor probably belongs to the same meteor shower. Furthermore, the higher D_{SH} (M, N) threshold picked up one possible member, s8504 = NMS432, from among the IAU photographic meteor orbit data, of which linear elements indicate strong hyperbola, probably due to overestimating the atmospheric deceleration. The orbital, radiant and geocentric velocity data of these meteors along with the mean ones based on the four probable members above are given in Table 1: where EN030895, a −8 mag. fireball, was the largest of all, with a photometric mass estimated to be ~ 30 g as against those of the other TV and photographic meteoroids ranging in the order of 10^{-3} ~ 1 g. The orbital spread of the central part based on S. D. is almost comparable to those of the other annual meteor showers: e.g., η Aquarids [8]; Perseids [9]; etc.

These optical observations ascertain the existence of a certain meteor shower, and then, we may designate this meteor shower as " η Eridanids" after their radiant locations.

2.2 Visual and Radar observations

Considering the radiant's daily motion, we could find some η Eridanid activities among visual meteor data: Hoffmeister's [10] no. 276, maximum at solar long. = 140°, radiant α = 42°, δ = −17° (equinox 1925.0); McIntosh's [11] no. 23, active July 29−Aug. 4, radiant α = 39°, δ = −16° (equinox 1900.0); Sakaguchi's [12] observation, on Aug. 5.76 UT, 1998, radiant α = 44°, δ = −11° (equinox J2000), zenithal hourly rate ~ 6, comparable angular velocities with the Perseids; etc.

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Table 1. Orbital data of the η Eridanids and the parent candidates (equinox J2000)

Object name	Yr	Day UT Aug.	a AU	e	q AU	ω	Ω	i	Radiant α	Radiant δ	V_G km s^{-1}
EN030895	95	3.05950	14.	0.932	0.956	28.4	310.339	130.9	38.4	-14.8	63.8
DMS93168	93	12.06070	-49.17	1.02	0.958	26.9	319.452	137.2	45.5	- 8.7	66.3
T9408-05	94	12.74340	174.85	0.995	0.964	25.5	319.867	127.5	47.6	-14.1	63.7
MSSIQN	96	12.72543	7.11	0.864	0.968	25.4	320.3	126.1	48.7	-14.1	62.1
s8504	85	13.71257	-2.8	1.33	0.945	28.4	321.09	136.7	45.2	- 9.7	69.1
mean		10.14726	20.26	0.953	0.961	26.6	317.490	130.4	45.0	-12.9	64.0
S.D.		4.10136		0.060	0.005	1.2	4.139	4.3	4.0	2.4	1.5
Ob355	68	Jul28-Aug3	3.85	0.75	0.96	28.7	307.4	133.4	36.6	-13.4	62.6
D/1827M1		13	16.26	0.950	0.807	19.311	320.061	136.452	48.8	- 8.2	65.5
C/1852K1		13	∞	1	0.905	37.206	319.271	131.124	43.2	-12.5	64.3

note. angular data of s8504 and Ob355 were converted from B1950 to J2000. The perihelion times of D/1827M1 and C/1852K1 are 1827 June 7.703 TT (epoch June 13.0 TT) and 1852 Apr. 20.09 UT, respectively.

On the other hand, we could notice an only record of the radar η Eridanids. This is Ob355 recorded by the Obninsk radar orbit survey [13]: mean data based on 6 radar meteors as shown in Table 1, where it can be seen that the orbital data of Ob355 are very similar to those of our η Eridanids, especially EN030895, except for the linear elements. It should also be noted that 1/a = 0.26 ± 0.06 AU^{-1} of Ob355 is significantly larger than 1/a = 0.0494 ± 0.0624 AU^{-1} of the optical data. This may be caused by a possible mass sorting effect inside the η Eridanid stream.

Therefore, these visual and radar observations sufficiently reinforce the existence of the η Eridanids. Nevertheless, descriptions of the η Eridanids have never been given in any well-known meteor shower catalogues yet. Hence, we can regard the η Eridanids to be a newly discovered meteor shower in the present study.

3. PARENT CANDIDATES: PERIODIC COMET PONS-GAMBART AND COMET CHACORNAC

We surveyed whether a parent comet of the η Eridanids exists or not from the "Catalogue of Cometary Orbits" [14]; consequently, we could find Periodic Comet Pons-Gambart D/1827M1 and Comet Chacornac C/1852K1 as parent candidates.

D/1827M1 was independently discovered in Hercules by J. L. Pons at Florence and J. F. A. Gambart at Marseilles during their telescopic-aided visual comet searches on June 20, 1827, when the magnitude was as bright as 5 ~ 6. Since the absolute magnitude H_{10} was estimated at ~ 7 [15], we may suppose Comet Pons-Gambart to be of an ordinary size as a comet nucleus. The periodic orbits of 46.0 and 63.8 years were computed by Ogura [16]; the latter orbital period should be more reliable. The 1827 return has only been observed and recorded so far; hence, Comet Pons-Gambart is regarded as a lost comet. However, Hasegawa [17] first pointed out a possible identification of Comet 1110K1 with D/1827M1, comparing their orbital similarity. Furthermore, Hasegawa and Nakano [18] successfully linked both orbits, integrating the comet's motion, and they also derived the improved periodic orbit of 65.6 years for D/1827M1 from 50 best positions. This orbital period is nearly equal to that of Ogura's 63.8 years. If the comet had returned 12 times between 1110-1827, the positional O−C residuals for the naked-eye observations in 1110 return should be 0.7° arc: it is smaller than those of 1° arc for Keglar's naked-eye observations in the 1737 return of Periodic Comet Swift-Tuttle 109P/1862O1 = 1992S2 [19]. There is another similar example; Carusi et al. [20] could link Comet La Hire 1678R1 (O−C residuals ~ 0.2° arc in spite of naked-eye observations) with Periodic Comet d'Arrest 6P/1851M1, which should return 25 unobserved times between 1678-1851. Therefore, the linkage of C/1110K1 with D/1827M1 seems very likely if the nongravitational parameters, acting effectively on the Cometary motion, were very small during that interval. According to Hasegawa and Nakano [18], the next return of Comet Pons-Gambart is expected to be in late January, 2022; however, the conditions for observation will be not so good as those in 1110 and

1827 then.

On the other hand, C/1852K1 was discovered in Cepheus by Chacornac at Marseilles during his telescopic-aided visual comet search on May 16, 1852; then the magnitude was 9 ~ 10. Its H_{10} was estimated at ~ 10 [15], which may imply a smaller nucleus than Comet Pons-Gambart. Afterwards, Asten [21] determined the parabolic orbit of C/1852K1.

4. COMET-METEOR ASSOCIATION

D_{SH} between D/1827M1-mean η Eridanids being 0.24 as against that between C/1852K1-mean η Eridanids being 0.18: both are within a possible range of association. Especially, D_{SH} between C/1852K1-EN030895 is smallest, 0.15, among all the comet-meteor pairs presented here, hence presumably associated with each other. Both comets closely approach the Earth's orbit at their ascending nodes, where the distances of the orbits between each comet and Earth, based on Hasegawa's [22] ω - and q-adjustment methods, are 0.39 AU and 0.19 AU respectively for D/1827M1, while smaller again 0.012 AU and 0.007 AU respectively for C/1852K1, making the meteor apparitions associated with C/1852K1 more favorable. The orbital data of Comet Pons-Gambart D/1827M1 [18] and Comet Chacornac C/1852K1 [21] along with their q-adjustment meteor predictions are also given in Table 1.

Kronk [23] also pointed out an orbital similarity between Comet Pons-Gambart D/1827M1 and his discovered August Eridanids. However, the orbital elements of this meteor shower are somewhat different from those of our η Eridanids, and then, D_{SH} between D/1827M1-August Eridanids reaches ~ 0.4, evidently being out of the association range.

Since Comet Pons-Gambart is one of the short-period comets with an orbital period ~ 65 yr, we next investigated whether the meteoroids ejected from Comet Pons-Gambart in the past encountered the Earth's orbit or not, using the ejection velocity V_E formula (Eq. 1) of Brown and Jones [24]:

$$V_E = 10.2\, r^{-1.038}\, \rho^{-1/3} R^{1/2} m^{-1/6} \qquad (1)$$

where r is the heliocentric distance, ρ is the bulk density of the meteoroid, R is the radius of the cometary nucleus and m is the mass of the meteoroid. The adopted values here are r = 0.838 AU, ρ ~ 800 kg m^{-3}, R ~ 1 km (assumed) and m ~ 0.1 g (typical photographic η Eridanid), respectively, which result in V_E ~ 10 m s^{-1}. We performed the forward numerical integrations of motions of such isotropically-ejected meteoroids from 195 BC to AD 3000. The initial orbital data of the comet were taken from Hasegawa and Nakano [18]. As an integrator, Schubart-Stumpff's [25] method in double precision was applied, along with a time step of 0.5 day. All the nine major planets were included as perturbing bodies, of which initial coordinates were taken from the JPL Planetary and Lunar Ephemeris DE406. As a result in our model, no meteoroids encountered the Earth's orbit within 0.1 AU in this term; that is to say, meteor appearances associated with Comet Pons-Gambart would be unrealistic, judging from our 3000-y trace, while such larger meteoroids ejected from other short-period comets, e.g., 109P and 55P, can evolve into the Earth-crossing dust swarm within their several orbital revolutions, consequently being observable as the Perseids and the Leonids, respectively [24][26].

We conclude on the basis of the investigations above that Comet Chacornac, rather than Comet Pons-Gambart, seems to be possibly associated with the η Eridanids. It is no wonder that such a long-period comet as Comet Chacornac accompanies an associated meteor stream since several cases were confirmed [27]. However, D_{SH} between Comet Chacornac- η Eridanids is still somewhat larger than those of the other confirmed comet-meteor associations. Therefore, obtaining and analyzing more orbital data of the η Eridanids should clarify this problem.

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