N79-19453

# 17. A Working List of Meteor Streams

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THIS WORKING LIST which starts on the next page has been compiled from the following sources:

(1) A selection by myself (Cook, 1973) from a list by Lindblad (1971a), which he found from a computer search among 2401 orbits of meteors photographed by the Harvard Super-Schmidt cameras in New Mexico (McCrosky and Posen, 1961)

(2) Five additional radiants found by McCrosky and Posen (1959) by a visual search among the radiants and velocities of the same 2401 meteors

(3) A further visual search among these radiants and velocities by Cook, Lindblad, Marsden, McCrosky, and Posen (1973)

(4) A computer search by Lindblad (1971b) among 1827 precisely reduced photographed meteors from all available sources

(5) Visual radiants reported by Hoffmeister (1948)

(6) A report on the Phoenicid shower of December 5, 1956, by Ridley (1962)

(7) A list of visual radiants by McIntosh (1935)

(8) A report on the June Lyrids by Hindley (1969)

(9) Two papers on radar radiants in the southern sky by Weiss (1960a, b)

(10) A paper on radar radiants in the southern hemisphere by Nilsson (1964)

(11) Several compilations of visual, photographic, and radar radiants by Whipple and Hawkins (1959), McKinley (1961), Millman and McKinley (1963), and Jacchia (1963)

This list is restricted to streams that the author is convinced do exist. It is perhaps still too comprehensive in that there are six streams with activity near the threshold of detection by photography not related to any known comet and not shown to be active for as long as a decade. Unless activity can be confirmed in earlier or later years or unless an associated comet appears, these streams should probably be dropped from a later version of this list. The author will be much more receptive to suggestions for deletions from this list than he will be to suggestions for additions to it. Clear evidence that the threshold for visual detection of a stream has been passed (as in the case of the June Lyrids) should qualify it for permanent inclusion.

A comment on the matching sets of orbits is in order. It is the directions of perihelion that should match, a condition clearly met in most cases:

(1) April Lyrids and Comet 1861 I Thatcher

(2) $\eta$ Aquarids, Orionids, and P/Comet Halley

(3) $\tau$ Herculids and Comet 1930 VI Schwassmann-Wachmann 3

(4) Daytime $\beta$ Taurids, Southern Taurids, Northern Taurids, and P/Comet Encke

(5) June Boötids and P/Comet Pons-Winnecke 1915 III

(6) o Draconids and Comet 1919 V Metcalf

(7) Southern and Northern $\iota$ Aquarids

(8) Perseids and Comet 1862 III Swift-Tuttle

(9) Aurigids and Comet 1911 II Kiess

(10) Daytime Sextantids and Geminids

(11) Annual Andromedids and the predicted orbit of P/Comet Biela for 1972

(12) Andromedids and P/Comet Biela 1852 III

I.—*Working List of Meteor Streams*

| Name | Dates[a] | Max. | Longitude of Sun (1950) | | | | | Geocentric radiant | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Beginning (deg) | Half max. (deg) | Max. (deg) | Half max. (deg) | End (deg) | R.A. 1950 (deg) | Decl. 1950 (deg) | Velocity (km s$^{-1}$) | Sun (deg) |
| Quadrantids | Jan. 1–4 | Jan. 3 | 280.8 | 282.5 | 282.7 | 282.9 | 283.4 | 230.1 | +48.5 | 41.5 | 282.7 |
| δ Cancrids | Jan. 13–21 | Jan. 16 | 293 | | 296 | | 301 | 126 | +20 | 28 | 296 |
| Virginids | Feb. 3–Apr. 15 | | 314 | | | | 25 | 186 | 0 | 35 | 350 |
| δ Leonids | Feb. 5–Mar. 19 | Feb. 26 | 316 | | 338 | | 359 | 159 | +19 | 23 | 338 |
| Camelopardalids | Mar. 14–Apr. 7 | | 353 | | | | 17 | 118.7 | +68.3 | 6.8 | 359.0 |
| σ Leonids | Mar. 21–May 13 | Apr. 17 | 1 | | 27 | | 52 | 195 | − 5 | 20 | 28 |
| δ Draconids | Mar. 28–Apr. 17 | | 7 | | | | 27 | 281 | +68 | 26.7 | 14 |
| κ Serpentids | Apr. 1–7 | | 11 | | | | 17 | 230 | +18 | 45 | 14 |
| μ Virginids | Apr. 1–May 12 | Apr. 25 | 12 | | 35 | | 51 | 221 | − 5 | 29 | 35 |
| α Scorpiids | Apr. 11–May 12 | May 3 | 21 | | 42 | | 51 | 240 | −22 | 35 | 42 |
| α Boötids | Apr. 14–May 12 | Apr. 28 | 24 | | 36 | | 51 | 218 | +19 | 20 | 36 |
| φ Boötids | Apr. 16–May 12 | May 1 | 26 | | 40 | | 51 | 240 | +51 | 12 | 40 |
| April Lyrids | Apr. 20–23 | Apr. 22 | 30.7 | 31.2 | 31.7 | 32.2 | 32.7 | 271.4 | +33.6 | 47.6 | 31.7 |
| η Aquarids | Apr. 21–May 12 | May 3 | 30 | 39 | 42.4 | 45 | 51 | 335.6 | − 1.9 | 65.5 | 42.4 |
| τ Herculids | May 19–June 14 | June 3 | 58 | | 72 | | 83 | 228 | +39 | 15 | 72 |
| χ Scorpiids | May 27–June 20 | June 5 | 65 | | 74 | | 89 | 247 | −13 | 21 | 74 |
| Daytime Arietids | May 29–June 19 | June 7 | 67 | 71 | 76 | 83 | 88 | 44 | +23 | 37 | 77 |
| Daytime ζ Perseids | June 1–17 | June 7 | 70 | 72 | 76 | 83 | 86 | 62 | +23 | 27 | 78 |
| Librids | June 8–9, 1937 | June 8 | 77.6 | | 78.2 | | 78.4+ | 227.2 | −28.3 | 16±2 | 78.2 |
| Sagittariids | June 8–16, 1957–8 | June 11 | 77 | | 80 | | 82 | 304 | −35 | 52 | 80 |
| θ Ophiuchids | June 8–16 | June 13 | 77 | | 82 | | 85 | 267 | −28 | 26.7 | 82 |
| June Lyrids | June 11–21, 1969 | June 16 | 79 | 81 | 84.5 | 87.5 | 90 | 278 | +35 | 31±3 | 84.5 |
| Daytime β Taurids | June 24–July 6 | June 29 | 91 | 93 | 96 | 99 | 103 | 86 | +19 | 30 | 96 |
| Corvids | June 25–30, 1937 | June 26 | 94.8 | 94.9 | 95.2 | 97.6 | 97.9 | 191.9 | −19.1 | 10±2 | 95.9 |
| June Boötids | June 28, 1916 | June 28 | 97.5 | | 97.6 | | 97.7 | 219 | +49 | 13.9 | 98 |
| July Phoenicids | July 3–18 | July 14 | 101 | | 112 | | 116 | 31.1 | −47.9 | 47±3 | 109.6 |
| o Draconids | July 7–24 | July 16 | 104 | | | | 121 | 271 | +59 | 23.6 | 113 |
| Northern δ Aquarids | July 14–Aug. 25 | Aug. 12 | 111 | | 139 | | 152 | 339 | − 5 | 42.3 | 139 |
| Southern δ Aquarids | July 21–Aug. 29 | July 29 | 118 | 121 | 125 | 129 | 155 | 333.1 | −16.5 | 41.4 | 125.0 |
| α Capricornids | July 15–Aug. 10 | July 30 | 123 | | 126 | | 138 | 307 | −10 | 22.8 | 127 |
| Southern ι Aquarids | July 15–Aug. 25 | Aug. 5 | 112 | | 131 | | 151 | 333.3 | −14.7 | 33.8 | 131.0 |
| Northern ι Aquarids | July 15–Sept. 20 | Aug. 20 | 112 | | 147 | | 177 | 327 | − 6 | 31.2 | 147 |
| Perseids | July 23–Aug. 23 | Aug. 12 | 120 | 138 | 139 | 141 | 150 | 46.2 | +57.4 | 59.4 | 139.0 |
| κ Cygnids | Aug. 9–Oct. 6 | Aug. 18 | 136 | | 145 | | 193 | 286 | +59 | 24.8 | 145 |
| Southern Piscids | Aug. 31–Nov. 2 | Sept. 20 | 158 | | 177 | | 219 | 6 | 0 | 26.3 | 177 |
| Northern Piscids | Sept. 25–Oct. 19 | Oct. 12 | 182 | | 199 | | 206 | 26 | +14 | 29 | 199 |
| Aurigids | Sept. 1, 1935 | Sept. 1 | | | 157.9 | | | 84.6 | +42.0 | 66.3 | 157.9 |
| κ Aquarids | Sept. 11–28 | Sept. 21 | 168 | | 178 | | 184 | 338 | − 5 | 16.0 | 178 |
| Southern Taurids | Sept. 15–Nov. 26 | Nov. 3 | 172 | | 220 | | 244 | 50.5 | +13.6 | 27.0 | 220.0 |

I.—*Working List of Meteor Streams*—Continued

| Name | Dates[a] | Max. | Longitude of Sun (1950) | | | | | Geocentric radiant | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Beginning (deg) | Half max. (deg) | Max. (deg) | Half max. (deg) | End (deg) | R.A. 1950 (deg) | Decl. 1950 (deg) | Velocity (km s$^{-1}$) | Sun (deg) |
| Northern Taurids | Sept. 19–Dec. 1 | Nov. 13 | 176 | 206 | 230 | 240 | 249 | 58.3 | +22.3 | 29.2 | 230.0 |
| Daytime Sextantids | Sept. 24–Oct. 5 | Sept. 29 | 179 | | 184 | | 190 | 152 | 0 | 32.2 | 183.6 |
| Annual Andromedids | Sept. 25–Nov. 12 | Oct. 3 | 182 | 184 | 190 | 195 | 230 | 5 | + 8 | 23.2 | 190 |
| | | | | | | | | 20 | +34 | 18.2 | 228 |
| Andromedids | Nov. 27, 1885 | Nov. 27 | 246.6 | 246.65 | 246.7 | 246.75 | 246.8 | 25 | +44 | 16.5 | 247 |
| Orionids | Oct. 2–Nov. 7 | Oct. 21 | 189 | 206.7 | 207.7 | 208.3 | 225 | 94.5 | +15.8 | 66.4 | 208.0 |
| October Draconids | Oct. 9 | Oct. 9 | 196.25 | | 196.3 | | 196.35 | 262.1 | +54.1 | 20.43 | 196.3 |
| ε Geminids | Oct. 14–27 | Oct. 19 | 201 | | 206 | | 214 | 104 | +27 | 69.4 | 209 |
| Leo Minorids | Oct. 22–24 | Oct. 24 | 209 | | 211 | | 211 | 162 | +37 | 61.8 | 211 |
| Pegasids | Oct. 29–Nov. 12 | Nov. 12 | 215 | | 230 | | 230 | 335 | +21 | 11.2 | 230 |
| Leonids | Nov. 14–20 | Nov. 17 | 231 | 234.447 | 234.462 | 234.477 | 237 | 152.3 | +22.2 | 70.7 | 234.5 |
| Monocerotids | Nov. 27–Dec. 17 | Dec. 10 | 245 | | 258 | | 265 | 99.8 | +14.0 | 42.4 | 257.6 |
| σ Hydrids | Dec. 3–15 | Dec. 11 | 251 | | 259 | | 263 | 126.6 | + 1.6 | 58.4 | 259.0 |
| Northern χ Orionids | Dec. 4–15 | Dec. 10 | 252 | | 258 | | 261 | 84 | +26 | 25.2 | 258 |
| Southern χ Orionids | Dec. 7–14 | Dec. 11 | 255 | | 259 | | 262 | 85 | +16 | 25.5 | 259 |
| Geminids | Dec. 4–16 | Dec. 14 | 252 | 260.6 | 261.7 | 262.1 | 264.2 | 112.3 | +32.5 | 34.4 | 261.0 |
| December Phoenicids | Dec. 5, 1956 | Dec. 5 | 253.18 | 253.45 | 253.55 | 253.65 | 253.70 | 15 | −55 | 21.7 | 253 |
| | | | | | | | | 15 | −45 | 11.7 | 254 |
| δ Arietids | Dec. 8–14 | | 256 | | | | 262 | 52 | +22 | 13.2 | 257.6 |
| Coma Berenicids | Dec. 12–Jan. 23 | | 260 | | | | 303 | 175 | +25 | 65 | 282 |
| Ursids | Dec. 17–24 | Dec. 22 | 265 | 269 | 270 | 271 | 272 | 217.06 | +75.85 | 33.4 | 270.66 |

[a] Unless otherwise indicated, all calendar dates are for the year 1950.

II.—*Working List of Meteor Streams*

| Name | Daily motion of radiant | | Number in sample of McCrosky and Posen (1961) | Maximum visual zenithal rate (hr$^{-1}$) | Maximum radar echo rate (hr$^{-1}$) |
|---|---|---|---|---|---|
| | R.A. (deg) | Decl. (deg) | | | |
| Quadrantids | | | 17 | 140 | |
| δ Cancrids | | | 7 | | |
| Virginids | +0.81 | −0.33 | 6 | | |
| δ Leonids | +0.75 | −0.50 | 24 | | |
| Camelopardalids | +1.35 | +0.51 | 4 | | |
| σ Leonids | +0.44 | +0.11 | 19 | | |
| δ Draconids | | | 4 | | |

| Name | Daily motion of radiant R.A. (deg) | Daily motion of radiant Decl. (deg) | Number in sample of McCrosky and Posen (1961) | Maximum visual zenithal rate ($hr^{-1}$) | Maximum radar echo rate ($hr^{-1}$) |
|---|---|---|---|---|---|
| κ Serpentids | | | 4 | | |
| μ Virginids | +0.53 | −0.30 | 7 | | |
| α Scorpiids | +0.50 | −0.19 | 5 | | |
| α Boötids | +0.7 | +0.2 | 8 | | |
| φ Boötids | | | 6 | | |
| April Lyrids | +1.1 | 0.0 | 5 | 12 | |
| | | | | 96(1922) | |
| η Aquarids | +0.9 | +0.4 | 7 | 30 | |
| τ Herculids | −0.1 | +0.9 | 14 | | |
| χ Scorpiids | +0.9 | +0.5 | 11 | | |
| Daytime Arietids | +0.7 | +0.6 | | | 60 |
| Daytime ζ Perseids | +1.1 | +0.4 | | | 40 |
| Librids | | | | 10(1937) | |
| Sagittariids | | | | | 30 |
| θ Ophiuchids | | | 4 | 2 | |
| June Lyrids | | | | 9 | |
| Daytime β Taurids | +0.8 | +0.4 | | | 30 |
| Corvids | | | | 13(1937) | |
| June Boötids | | | | 100(1916) | |
| July Phoenicids | +1.04 | +0.53 | | | 30 |
| o Draconids | | | 3 | | |
| Northern δ Aquarids | +1.0 | +0.2 | 9 | 20 | |
| Southern δ Aquarids | +0.80 | +0.18 | 13 | 30 | |
| α Capricornids | +0.9 | +0.3 | 21 | 30 | |
| Southern ι Aquarids | +1.07 | +0.18 | 12 | 15 | |
| Northern ι Aquarids | +1.03 | +0.13 | 3 | 15 | |
| Perseids | +1.35 | +0.12 | 45 | 70 | |
| κ Cygnids | 0.0 | 0.0 | 8 | 5 | |
| Southern Piscids | | | 14 | | |
| Northern Piscids | | | 9 | | |
| Aurigids | | | | 30 | |
| κ Aquarids | | | 5 | | |
| Southern Taurids | +0.79 | +0.15 | 46 | 7 | |
| Northern Taurids | +0.76 | +0.10 | 45 | <7 | |
| Daytime Sextantids | | | | | 30 |
| Annual Andromedids | +0.38 | +0.66 | 23 | | |
| Andromedids | | | | 13 000(1885) | |
| Orionids | +1.23 | +0.13 | | 30 | |
| October Draconids | | | 2 | 30 000(1933) | |
| ε Geminids | +0.7 | 0.0 | 7 | | |
| Leo Minorids | | | 3 | | |
| Pegasids | | | 6 | | |
| Leonids | +0.70 | −0.42 | 5 | 14 000(1833) | |
| Monocerotids | | | 3 | | |
| σ Hydrids | +0.7 | −0.2 | 8 | | |
| Northern χ Orionids | | | 4 | | |
| Southern χ Orionids | | | 8 | | |
| Geminids | +1.02 | −0.07 | 77 | 70 | |
| December Phoenicids | | | | 100 | 20 |
| δ Arietids | | | 7 | | |
| Coma Berenicids | +0.88 | −0.45 | 11 | | |
| Ursids | | | | 20 | |
| | | | | 110(1945) | |

III.—*Working List of Meteor Streams*

| Name | Orbital elements | | | | | | |
|---|---|---|---|---|---|---|---|
| | $a$ | $e$ | $q$ | $\omega$ (deg) | $\Omega$ (deg) | $\iota$ (deg) | $\pi$ (deg) |
| Quadrantids | 3.08 | 0.683 | 0.977 | 170.0 | 282.7 | 72.5 | 92.8 |
| $\delta$ Cancrids | 2.3 | 0.80 | 0.45 | 283 | 296 | 0 | 219 |
| Virginids | 2.63 | 0.90 | 0.26 | 304 | 350 | 3 | 294 |
| $\delta$ Leonids | 2.62 | 0.75 | 0.64 | 259 | 338 | 6 | 237 |
| Camelopardalids | 1.534 | 0.352 | 0.974 | 185.0 | 359.0 | 8.2 | 184.0 |
| $\sigma$ Leonids | 2.35 | 0.66 | 0.75 | 248 | 28 | 1 | 276 |
| $\delta$ Draconids | 2.770 | 0.640 | 0.996 | 171.1 | 13.7 | 37.5 | 184.8 |
| $\kappa$ Serpentids | $\infty$ | 1.00 | 0.45 | 275 | 14 | 64 | 289 |
| $\mu$ Virginids | 3.12 | 0.83 | 0.48 | 280 | 35 | 10 | 315 |
| $\alpha$ Scorpiids | 2.15 | 0.90 | 0.21 | 134 | 222 | 3 | 356 |
| $\alpha$ Boötids | 2.65 | 0.71 | 0.75 | 247 | 36 | 18 | 283 |
| $\phi$ Boötids | 1.25 | 0.24 | 0.95 | 226 | 40 | 19 | 266 |
| April Lyrids | 28 | 0.968 | 0.919 | 214.3 | 31.7 | 79.0 | 246.0 |
| Comet 1861 I | 55.7 | 0.983 | 0.921 | 213.4 | 31.2 | 79.8 | 244.6 |
| $\eta$ Aquarids | 13 | 0.958 | 0.560 | 95.2 | 42.4 | 163.5 | 137.6 |
| Orionids | 15.1 | 0.962 | 0.571 | 82.5 | 28.0 | 163.9 | 110.5 |
| P/Comet Halley 1835 III | 18.0 | 0.967 | 0.587 | 110.7 | 56.8 | 162.3 | 167.5 |
| $\tau$ Herculids | 2.70 | 0.63 | 0.97 | 204 | 72 | 19 | 276 |
| Comet 1930 VI | 3.09 | 0.673 | 1.011 | 192.3 | 77.1 | 17.4 | 269.4 |
| $\chi$ Scorpiids | 3.11 | 0.77 | 0.68 | 257 | 74 | 6 | 331 |
| Daytime Arietids | 1.6 | 0.94 | 0.09 | 29 | 77 | 21 | 106 |
| Northern $\delta$ Aquarids | 2.62 | 0.97 | 0.07 | 332 | 139 | 20 | 111 |
| Southern $\delta$ Aquarids | 2.86 | 0.976 | 0.069 | 152.8 | 305.0 | 27.2 | 97.8 |
| Daytime $\zeta$ Perseids | 1.6 | 0.79 | 0.34 | 59 | 78 | 0 | 137 |
| Southern Piscids | 2.33 | 0.82 | 0.42 | 107 | 357 | 2 | 104 |
| Northern Piscids | 2.06 | 0.80 | 0.40 | 291 | 199 | 3 | 130 |
| Librids | 2.5/10 | 0.65/0.92 | 0.88/0.85 | 46/49 | 258.2 | 4/5 | 305/308 |
| Sagittariids | $\infty$ | 1.00 | 0.10 | 142 | 260 | 99 | 42 |
| $\theta$ Ophiuchids | 2.90 | 0.84 | 0.46 | 101 | 262 | 4 | 4 |
| June Lyrids | 2.5/10 | 0.67/0.92 | 0.83/0.84 | 237/231 | 84.5 | 44/50 | 321/315 |
| Daytime $\beta$ Taurids | 2.2 | 0.85 | 0.34 | 246 | 276.4 | 6 | 162 |
| Southern Taurids | 1.93 | 0.806 | 0.375 | 113.2 | 40.0 | 5.2 | 153.2 |
| Northern Taurids | 2.59 | 0.861 | 0.359 | 292.3 | 230.0 | 2.4 | 162.3 |
| P/Comet Encke 1970*l* | 2.217 | 0.847 | 0.339 | 185.9 | 334.2 | 12.0 | 160.1 |
| Corvids | 2.5/10 | 0.60/0.90 | 1.013/1.012 | 7.6/7.9 | 274.9 | 3/4 | 282.5/282.8 |
| June Boötids | 3.27 | 0.69 | 1.02 | 180 | 98 | 18 | 278 |
| P/Comet Pons-Winnecke 1915 III | 3.261 | 0.702 | 0.971 | 172.4 | 99.8 | 18.3 | 272.2 |
| July Phoenicids | 2.5/$\infty$ | 0.62/1.00 | 0.96/0.97 | 31/24 | 289.6 | 82/87 | 321/313 |
| o Draconids | $\infty$ | 1.00 | 1.01 | 190 | 113 | 43 | 303 |
| Comet 1919 V | $\infty$ | 1.000 | 1.115 | 185.7 | 121.4 | 46.4 | 307.2 |
| $\alpha$ Capricornids | 2.53 | 0.77 | 0.59 | 269 | 127 | 7 | 36 |
| Southern $\iota$ Aquarids | 2.36 | 0.912 | 0.208 | 131.8 | 311.0 | 6.9 | 82.8 |
| Northern $\iota$ Aquarids | 1.75 | 0.84 | 0.26 | 308 | 147 | 5 | 95 |
| Perseids | 28 | 0.965 | 0.953 | 151.5 | 139.0 | 113.8 | 290.5 |
| Comet 1862 III | 24.3 | 0.960 | 0.963 | 152.8 | 138.7 | 113.6 | 291.5 |
| $\kappa$ Cygnids | 3.09 | 0.68 | 0.99 | 194 | 145 | 38 | 339 |
| Aurigids | $\infty$ | 1.000 | 0.802 | 121.5 | 157.9 | 146.4 | 279.4 |
| Comet 1911 II | 153 | 0.996 | 0.684 | 110.3 | 158.0 | 148.4 | 268.3 |
| $\kappa$ Aquarids | 3.20 | 0.74 | 0.81 | 236 | 178 | 2 | 54 |

III.—*Working List of Meteor Streams*—Concluded

| Name | Orbital elements | | | | | | |
|---|---|---|---|---|---|---|---|
| | $a$ | $e$ | $q$ | $\omega$ (deg) | $\Omega$ (deg) | $\iota$ (deg) | $\pi$ (deg) |
| Daytime Sextantids | 1.25 | 0.87 | 0.16 | 213 | 3.6 | 22 | 217 |
| Geminids | 1.36 | 0.896 | 0.142 | 324.3 | 261.0 | 23.6 | 225.3 |
| Annual Andromedids | 3.22 | 0.82 | 0.58 | 267 | 190 | 4 | 97 |
| | 3.29 | 0.76 | 0.79 | 238 | 228 | 12 | 106 |
| P/Comet Biela (1972) | 3.54 | 0.77 | 0.82 | 255 | 213 | 8 | 108 |
| Andromedids | 3.53 | 0.76 | 0.86 | 222 | 247 | 13 | 109 |
| P/Comet Biela 1852 III | 3.52 | 0.756 | 0.861 | 223.2 | 247.3 | 12.6 | 110.4 |
| October Draconids | 3.51 | 0.717 | 0.996 | 171.8 | 196.3 | 30.7 | 8.1 |
| P/Comet Giacobini-Zinner 1946 V | 3.51 | 0.717 | 0.996 | 171.8 | 196.3 | 30.7 | 8.1 |
| $\epsilon$ Geminids | 26.77 | 0.97 | 0.77 | 237 | 209 | 173 | 86 |
| Leo Minorids | 58.6 | 0.99 | 0.65 | 106 | 211 | 124 | 317 |
| Comet 1739 | ∞ | 1.00 | 0.674 | 104.8 | 210.3 | 124.3 | 315.1 |
| Pegasids | 3.86 | 0.75 | 0.97 | 196 | 230 | 8 | 65 |
| December Phoenicids | 2.96 | 0.68 | 0.98 | 0 | 73 | 16 | 74 |
| | 2.96 | 0.67 | 0.99 | 359 | 74 | 13 | 72 |
| Comet 1819 IV | 2.96 | 0.699 | 0.892 | 350.2 | 79.2 | 9.1 | 69.4 |
| Leonids | 11.5 | 0.915 | 0.985 | 172.5 | 234.5 | 162.6 | 47.0 |
| P/Comet Tempel-Tuttle 1965 IV | 10.27 | 0.904 | 0.982 | 172.6 | 232.4 | 162.7 | 45.7 |
| Monocerotids | 42 | 0.997 | 0.14 | 135.8 | 77.6 | 24.8 | 213.4 |
| Comet 1917 I | 27.65 | 0.993 | 0.190 | 121.3 | 88.0 | 32.7 | 209.6 |
| $\sigma$ Hydrids | 30.0 | 0.992 | 0.244 | 120.7 | 79.0 | 125.5 | 199.8 |
| Northern $\chi$ Orionids | 2.22 | 0.79 | 0.47 | 281 | 258 | 2 | 179 |
| Southern $\chi$ Orionids | 2.18 | 0.78 | 0.47 | 101 | 79 | 7 | 180 |
| $\delta$ Arietids | 2.13 | 0.605 | 0.838 | 232.8 | 257.6 | 1.8 | 130.4 |
| Coma Berenicids | ∞ | 1.00 | 0.58 | 258 | 282 | 134 | 180 |
| Ursids | 5.70 | 0.85 | 0.9389 | 205.85 | 270.66 | 53.6 | 116.51 |
| P/Comet Tuttle 1939 X | 5.70 | 0.821 | 1.023 | 207.0 | 269.8 | 54.6 | 116.8 |

(13) October Draconids and P/Comet Giacobini-Zinner 1946 V

(14) Leo Minorids and Comet 1739 Zanotti

(15) Pegasids, December Phoenicids, and Comet 1819 IV Blanplain

(16) Leonids and P/Comet Tempel-Tuttle 1965 IV

(17) Monocerotids and Comet 1917 I Mellish

(18) Northern and Southern $\chi$ Orionids

(19) Ursids and P/Comet Tuttle

In the case of the Sextantids and the Geminids, the temporary character of the Sextantids and the concentration and strength of the Geminids suggest two parent bodies for the streams. The similarities in the directions of perihelion, distances at perihelion, and semimajor axes then imply that these two parent bodies separated from a common body at an earlier time. In the case of the Pegasids, December Phoenicids, and Comet 1819 IV Blanplain, the strength, concentration, and single apparition of the December Phoenicids suggest that a small comet still exists; the presence of meteors in the orbital plane of the Pegasids suggests that another comet separated long ago from Comet 1819 IV. If we were in the presence of a broad distribution of meteoroids, there would be continuous activity from northern and southern radiants in October, November, and December.

In two cases some serious failure to match occurs. Among the Daytime Arietids, Northern $\delta$ Aquarids, and Southern $\delta$ Aquarids, it is clear that the Northern $\delta$ Aquarids do not fit and are dubious members of the system; and in the case of the Daytime $\zeta$ Perseids, Southern Piscids, and Northern Piscids, it is clear that the Southern Piscids do not fit and are dubious members of the system. The traditional association between the $\alpha$ Capricornids and P/Comet Honda-Mrkos-Pajdušáková is rejected, as the directions of perihelia diverge by nearly 30°.

Of the 57 entries in the list, two are additional radiants associated with P/Comet Encke and six more are associated with another radiant, each in the sense that they appear to come from the same parent body. One of these pairs is the $\eta$ Aquarids and Orionids associated with P/Comet Halley. Another is the pair of Andromedid radiants, one that of the great showers, the other that of the current weak annual stream matching the current predicted orbit of P/Comet Biela. The remaining four pairs are not associated with a comet; two are pairs of daylight and night showers—the Daytime Arietids with the Southern $\delta$ Aquarids and the Daytime $\zeta$ Perseids with the Northern Piscids. The remaining two are merely northern and southern branches of the same streams; these two cases are the $\iota$ Aquarids and the $\chi$ Orionids. Thus, we deal here with 49 separate streams. Two additional pairings appear to be at the level of parent meteoroid-shedding bodies having separated from a larger body at an earlier time. These pairings are the Daytime Sextantids with the Geminids and the Pegasids with the December Phoenicids, which in turn apparently came from Comet 1819 IV Blanplain. It appears that 47 initial parent bodies are required to explain the present list of streams. Some 15 of the 49 currently required parent bodies have been observed as Comets. Two are lost, and P/Comet Biela is perhaps the best target for an effort at recovery. Small asteroids might be searched for along the orbits of the Geminids and Sextantids, and comets might be searched for along the orbits of the highly concentrated Quadrantids, Librids, and Corvids. The other 29 parent objects are associated with weak or diffuse stream systems, so a search for them would be tantamount to a general search of the sky.

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## NOTES ON INDIVIDUAL STREAMS

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| Virginids, $\sigma$ Leonids, and $\mu$ Virginids | These streams are contributors to Hoffmeister's (1948) visual Virginids. |
| $\alpha$ Scorpiids | This stream is a contributor to Hoffmeister's (1948) Scorpius-Sagittarius system. |
| April Lyrids | This stream is a weak annual one at the threshold of detection for visual observers but has given stronger displays in 1884 (22 $hr^{-1}$), 1922 (96 $hr^{-1}$), and 1948 (20 $hr^{-1}$). |
| $\eta$ Aquarids and Orionids | At this inclination, $\Omega-\omega$ should be compared between orbits, not $\pi$. The three values are 307.4°, 305.5°, and 306.2° for the $\eta$ Aquarids, the Orionids, and P/Comet Halley, respectively. |
| $\tau$ Herculids | Some evidence exists that this stream was detected visually, its radiant being regarded as early activity of the June Boötids (Olivier, 1916; Smith, 1932). |
| $\chi$ Scorpiids | This stream is a contributor to Hoffmeister's (1948) Scorpius-Sagitarrius system. |
| Librids | This shower was observed only in 1937. Two sets of elements are given to present likely extremes. |
| Sagittariids | This shower was observed only by radar and only in 1958. It was absent in the years 1952 to 1956. |
| $\theta$ Ophiuchids | This stream is the maximum of Hoffmeister's (1948) Scorpius - Sagittarius system. |

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|---|---|
| June Lyrids | This weak visual stream has appeared only from 1966 onward (Hindley, 1969). Two sets of elements are given to present likely extremes. |
| Corvids | This shower was observed only in 1937. Two sets of elements are given to present likely extremes. Hoffmeister's Orbit I (1948, p. 122) for $a=2.5$ is incorrect. |
| June Boötids | This shower was strong only in 1916 (100 $hr^{-1}$) and showed 6 $hr^{-1}$ in 1921 (Hoffmeister, 1921). |
| July Phoenicids | This shower was observed only by radar from 1953 through 1958. It does not appear in visual lists, although it should if it is not a recent arrival at the Earth's orbit. Two sets of elements are given to present likely extremes. |
| $\alpha$ Capricornids | These are Weiss' (1960b) Capricornids. They are not resolvable visually from the Southern $\delta$ Aquarids. |
| Southern $\iota$ Aquarids | These are Weiss' (1960b) Piscis Austrinids. They are not resolvable visually from the Southern $\delta$ Aquarids. |
| Northern $\iota$ Aquarids | Early on, this shower is not resolvable visually from the Southern $\delta$ Aquarids, and in its feeble late stages, it contributes to Hoffmeister's (1948) visual Piscids. |
| Southern Piscids and Northern Piscids | These streams contribute to Hoffmeister's (1948) visual Piscids. |
| Aurigids | This shower was strong for 1 hr before morning twilight on one night only. |
| Southern Taurids and Northern Taurids | These streams cannot be resolved from one another visually. |
| Annual Andromedids | This stream begins its activity by contributing to Hoffmeister's (1948) visual Piscids and then moves northward toward the radiant of the famous Andromedid showers. Two radiants and sets of elements are given to display the changes during the Earth's passage through the stream. |
| Andromedids | Strong showers occurred on December 5, 1741; December 7, 1798 ($\sim$400 $hr^{-1}$); December 7, 1830; December 6, 1838 ($\sim$100 $hr^{-1}$); December 6, 1847 ($\sim$150 $hr^{-1}$); November 30, 1867; November 27, 1872; November 27, 1885 ($\sim$13,000 $hr^{-1}$); November 23, 1892 ($\sim$300 $hr^{-1}$); November 24, 1899 ($\sim$100 $hr^{-1}$); November 21, 1904 ($\sim$20 $hr^{-1}$); and November 15, 1940 ($\sim$30 $hr^{-1}$). |
| October Draconids | Strong showers occurred in 1927 (17 $hr^{-1}$), 1933 (30 000 $hr^{-1}$), 1946 (10 000 $hr^{-1}$), and 1952 (200 $hr^{-1}$). |
| Leonids | Strong showers occurred in 1799, 1832, 1833, 1834, 1839, 1866, 1867, 1868, 1898, 1901, 1903, 1961, 1965, 1966, and 1969. In other years, activity was very feeble. |
| December Phoenicids | This shower appeared only in 1965. The northern radiant is visual; the southern is from radar observations. |
| Coma Berenicids | The December portion of this stream is called the December Leo Minorids by Cook et al. (1972), but Lindblad (1971b) found bridging meteors that connect the December Leo Minorids to Coma Berenicids in January. |

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