DET KGL. DANSKE VIDENSKABERNES SELSKAB
MATEMATISK-FYSISKE MEDDELELSER, BIND XXII, NR. 1

# THE ORBIT OF COMET DU TOIT-NEUJMIN-DELPORTE (1941 e)

BY

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1945

Comet 1941 e was discovered by DU TOIT on July 18th, 1941, by NEUJMIN on July 25th and by DELPORTE on August 19th. It was observed until October 20th, and 54 accurate observations are available. Several provisional orbits have been computed; the basis of this improvement is the following system, computed by GROSCH:

$$\left.\begin{array}{l} \text{Osculation 1941 Aug. 29.0 U.T.} \\ T = 1941\ \text{July}\ 21.18766\ \text{U.T.} \\ \left.\begin{array}{ll} \omega = & 69°10'33''.3 \\ \Omega = & 229\ 37\ 7\ .2 \\ i = & 3\ 14\ 49\ .4 \end{array}\right\} 1941.0 \\ e = 0.5789569 \\ \mu = 0°.18099891 \\ a = 3.0951760 \\ P = 5^{y}.4456 \end{array}\right\} \text{I}$$

From these elements I computed the following ephemeris. The perturbations from Jupiter were taken into account with the aid of ENCKE's method. It gives $\alpha_{1950.0}$ and $\delta_{1950.0}$ when $t$—light time is used as argument.

| | | $0^h$ U. T. | | | |
|---|---|---|---|---|---|
| 1941 | $\alpha_{1950.0}$ | $\delta_{1950.0}$ | $r$ | $\Delta$ | Light time |
| July 20 | $20^h\ 1^m28^s.87$ | $-6°44'52''.7$ | 1.303 | 0.294 | 0. 0017 |
| 21 | 2 57 .44 | 35 14 .8 | | | |
| 22 | 4 25 .82 | 26 1 .8 | | | |
| 23 | 5 54 .03 | 17 14 .0 | | | |
| 24 | 7 22 .09 | 8 51 .9 | | | |
| 25 | 8 50 .03 | 6 0 55 .4 | 1.304 | 0.295 | 0 .0017 |
| 26 | 20 10 17 .86 | $-5$ 53 25 .1 | | | |

| 1941 | $\alpha_{1950.0}$ | $\delta_{1950.0}$ | $r$ | $\Delta$ | Light time |
|---|---|---|---|---|---|
| Aug. 16 | $20^h40^m52^s.76$ | $-4°48'31''.9$ | | | |
| 17 | 42 19 .65 | 49 6 .7 | | | |
| 18 | 43 46 .52 | 49 56 .0 | | | |
| 19 | 45 13 .40 | 50 58 .5 | 1.344 | 0.345 | 0.0020 |
| 20 | 46 40 .32 | 52 13 .3 | | | |
| 21 | 48 7 .26 | 53 39 .7 | | | |
| 22 | 49 34 .30 | 55 16 .5 | | | |
| 23 | 51 1 .41 | 57 2 .8 | | | |
| 24 | 52 28 .63 | 4 58 57 .6 | 1.359 | 0.365 | 0.0021 |
| 25 | 53 55 .98 | 5 1 0 .1 | | | |
| 26 | 55 23 .47 | 3 9 .2 | | | |
| 27 | 56 51 .13 | 5 23 .9 | | | |
| 28 | 58 18 .94 | 7 43 .5 | | | |
| 29 | 20 59 46 .95 | 10 7 .0 | 1.376 | 0.388 | 0.0022 |
| 30 | 21 1 15 .12 | 12 33 .5 | | | |
| 31 | 2 43 .48 | 15 2 .3 | | | |
| Sept. 1 | 4 12 .01 | 17 32 .7 | | | |
| 2 | 5 40 .72 | 20 3 .7 | | | |
| 3 | 21 7 9 .57 | $-5$ 22 35 .2 | 1.395 | 0.414 | 0.0024 |
| Sept. 7 | 21 13 6 .40 | $-5$ 32 29 .3 | | | |
| 8 | 14 35 .92 | 34 52 .3 | 1.416 | 0.444 | 0.0026 |
| 9 | 16 5 .58 | 37 11 .9 | | | |
| 10 | 17 35 .37 | 39 27 .6 | | | |
| 11 | 19 5 .28 | 41 39 .0 | | | |
| 12 | 20 35 .31 | 43 45 .7 | | | |
| 13 | 22 5 .49 | 45 47 .1 | 1.438 | 0.476 | 0.0027 |
| 14 | 23 35 .82 | 47 42 .9 | | | |
| 15 | 25 6 .30 | 49 32 .6 | | | |
| 16 | 26 36 .92 | 51 16 .0 | | | |
| 17 | 28 7 .71 | 52 52 .7 | | | |
| 18 | 29 38 .67 | 54 22 .3 | 1.462 | 0.513 | 0.0030 |
| 19 | 31 9 .80 | 55 44 .3 | | | |
| 20 | 32 41 .11 | 56 58 .8 | | | |
| 21 | 34 12 .62 | 58 5 .2 | | | |
| 22 | 35 44 .33 | 59 3 .4 | | | |
| 23 | 37 16 .25 | 5 59 53 .0 | 1.487 | 0.553 | 0.0032 |
| 24 | 38 48 .39 | 6 0 33 .7 | | | |
| 25 | 40 20 .74 | 1 5 .6 | | | |
| 26 | 41 53 .30 | 1 28 .3 | | | |
| 27 | 43 26 .07 | 1 41 .9 | | | |
| 28 | 44 59 .07 | 1 46 .1 | 1.514 | 0.596 | 0.0034 |
| 29 | 21 46 32 .20 | $-6$ 1 40 .8 | | | |

| 1941 | $\alpha_{1950.0}$ | $\delta_{1950.0}$ | $r$ | $\Delta$ | Light time |
|---|---|---|---|---|---|
| Oct. 11 | $22^h\ 5^m21^s.40$ | $-5°48'19''.2$ | | | |
| 12 | 6 56 .25 | 46 11 .5 | | | |
| 13 | 8 31 .21 | 43 54 .6 | 1.600 | 0.747 | 0.0043 |
| 14 | 10 6 .28 | 41 28 .5 | | | |
| 15 | 11 41 .44 | 38 53 .4 | | | |
| 16 | 13 16 .72 | 36 9 .1 | | | |
| 17 | 14 52 .10 | 33 16 .1 | | | |
| 18 | 22 16 27 .59 | −5 30 14 .0 | 1.631 | 0.805 | 0.0046 |

The following table gives the observations. The weights $p$ were found from curves drawn with $\Delta\alpha$ and $\Delta\delta$ as ordinates and times as abscissae.

| | | | | O—C | | |
|---|---|---|---|---|---|---|
| No. | $t$—light time | $\alpha_{1950.0}$ | $\delta_{1950.0}$ | $\Delta\alpha\cos\delta$ | $\Delta\delta$ | $p$ | |
| 1 | July 21.94483 | $20^h\ 4^m21^s.18$ | $-6°26'28''.0$ | $+6^s.23$ | $+3''.9$ | 1 | Würzburg |
| 2 | 22.00337 | 4 26 .5– | 25 56 .– | +0 .4– | +4 .– | 0 | Sonneberg |
| 3 | 22.03198 | 4 27 .58 | 25 25 .9 | −1 .06 | +18 .6 | 1 | Würzburg |
| 4 | 24.91471 | 8 41 .82 | 1 24 .3 | −0 .71 | +10 .7 | 1 | — |
| 5 | 24.98025 | 8 47 .69 | 0 45 .8 | −0 .60 | +18 .8 | 1 | — |
| 6 | 25.03649 | 8 50 .7– | 6 0 50 .– | −2 .5– | −12 .– | 0 | Sonneberg |
| 7 | Aug. 17.97581 | 43 45 .6– | 4 49 59 .– | +1 .2– | −4 .– | 2 | — |
| 8 | 19.85465 | 46 27 .84 | 52 4 .5 | +0 .16 | −2 .8 | 4 | Uccle |
| 9 | 19.89066 | 46 30 .43 | 52 4 .3 | −0 .38 | +0 .2 | 4 | — |
| 10 | 20.85883 | 47 54 .59 | 53 27 .3 | −0 .40 | −0 ·5 | 4 | — |
| 11 | 20.88549 | 47 57 .20 | 53 32 .4 | −0 .10 | −3 .2 | 4 | — |
| 12 | 20.90261 | 47 58 .80 | 53 32 .5 | +0 .01 | −1 .7 | 4 | — |
| 13 | 22.87201 | 50 49 .81 | 56 51 .1 | −0 .45 | −2 .4 | 4 | — |
| 14 | 22.89635 | 50 52 .17 | 57 54 .3 | −0 .21 | −3 .0 | 4 | — |
| 15 | 22.90210 | 50 52 .79 | 57 6 .9 | −0 .09 | −14 .9 | 4 | — |
| 16 | 23.96282 | 52 26 .0– | 4 59 17 .– | +0 .6– | −24 .– | 0 | Torino |
| 17 | 24.86235 | 53 43 .50 | 5 0 42 .5 | −0 .45 | +0 .3 | 4 | Uccle |
| 18 | 24.90509 | 53 47 .80 | 0 39 .0 | +0 .12 | +9 .1 | 1 | Torino |
| 19 | 26.92494 | 56 44 .48 | 5 15 .5 | −0 .06 | −1 .8 | 4 | Uccle |
| 20 | 27.17961 | 57 6 .8– | 5 53 .– | −0 .1– | −4 .– | 3 | Yerkes |
| 21 | 27.86642 | 58 6 .6– | 7 15 .– | −0 .6– | +10 .– | 2 | Barcelona |
| 22 | 27.95347 | 58 14 .67 | 7 36 .9 | −0 .18 | 0 .0 | 4 | Uccle |
| 23 | 28.11264 | 58 28 .67 | 8 0 .5 | −0 .17 | −1 .0 | 3 | Washington |
| 24 | 28.26938 | 58 42 .6– | 8 22 .– | 0 .0– | 0 .– | 3 | Yerkes |
| 25 | 28.90777 | 20 59 38 .56 | 9 56 .1 | −0 .26 | −2 .5 | 4 | Uccle |
| 26 | 30.90056 | 21 2 35 .10 | 14 41 .5 | +0 .42 | +5. 9 | 1 | Torino |
| 27 | 31.92046 | 4 4 .31 | 17 20 .7 | −0 .65 | 0 .0 | 2 | Posen |
| 28 | Sept. 1.85346 | 5 29 .87 | 19 58 .8 | +2 .16 | −17.3 | 0 | — |
| 29 | 8.82855 | 15 50 .02 | 36 45 .1 | −0 .18 | +3 .1 | 4 | Uccle |
| 30 | 9.82287 | 21 17 19 .30 | −5 38 59 .2 | −0 .16 | +4 .6 | 1 | Torino |

| No. | $t$—light time | $\alpha_{1950.0}$ | $\delta_{1950.0}$ | O—C $\Delta\delta\cos\delta$ | O—C $\Delta\delta$ | $p$ | |
|---|---|---|---|---|---|---|---|
| 31 | Sept. 11.05975 | $21^h19^m10^s.24$ | $-5°41'52''.9$ | $-0^s.42$ | $-6''.2$ | 3 | Yerkes |
| 32 | 11.81540 | 20 20 .76 | 43 20 .1 | +2 .08 | +2 .6 | 0 | Uccle |
| 33 | 11.84068 | 20 22 .30 | 43 22 .5 | +1 .34 | +3 .3 | 0 | — |
| 34 | 12.06600 | 20 41 .05 | 43 56 .5 | −0 .21 | −2 .6 | 3 | Yerkes |
| 35 | 15.81748 | 26 19 .57 | 50 34 .5 | −0 .80 | +23 .1 | 0 | Uccle |
| 36 | 15.84882 | 26 23 .57 | 50 50 .3 | +0 .36 | +10 .5 | 1 | Torino |
| 37 | 16.85134 | 27 53 .87 | 52 49 .0 | −0 .33 | −10 .3 | 1 | — |
| 38 | 17.81158 | 29 21 .17 | 54 3 .7 | −0 .35 | +2 .3 | 4 | Uccle |
| 39 | 17.83023 | 29 22 .78 | 54 4 .6 | −0 .44 | +3 .0 | 4 | — |
| 40 | 19.82196 | 32 24 .67 | 56 41 .8 | −0 .17 | +4 .3 | 4 | — |
| 41 | 19.84004 | 32 26 .75 | 56 57 .2 | +0 .26 | −9 .8 | 1 | Torino |
| 42 | 21.83026 | 35 28 .10 | 58 50 .2 | −0 .65 | +3 .9 | 4 | Uccle |
| 43 | 21.86139 | 35 31 .24 | 58 54 .3 | −0 .37 | +1 .5 | 2 | Posen |
| 44 | 22.87949 | 37 5 .48 | 59 55 .8 | +0 .32 | −8 .4 | 1 | Torino |
| 45 | 22.91306 | 37 8 .00 | 5 59 46 .5 | −0 .25 | +2 .5 | 3 | Wien |
| 46 | 23.81120 | 38 30 .41 | 6 0 27 .8 | −0 .57 | −1 .1 | 4 | Uccle |
| 47 | 23.84927 | 38 34 .55 | 0 36 .7 | +0 .06 | −8 .6 | 1 | Torino |
| 48 | 23.89737 | 38 38 .45 | 0 28 .1 | −0 .47 | +1 .8 | 3 | Wien |
| 49 | 24.92442 | 40 13 .23 | 1 2 .5 | −0 .52 | +1 .0 | 3 | — |
| 50 | 25.83195 | 41 37 .23 | 1 20 .3 | −0 .50 | +4 .8 | 4 | Uccle |
| 51 | 26.99327 | 43 14 .49 | 1 41 .6 | −10 .96 | +0 .2 | 0 | Wien |
| 52 | 27.84472 | 21 44 43 .56 | 6 1 48 .1 | −1 .07 | −2 .0 | 4 | Uccle |
| 53 | Oct. 12.79599 | 22 8 10 .14 | 5 44 25 .8 | −1 .69 | −2 .5 | 4 | — |
| 54 | 15.79004 | 22 12 54 .58 | −5 36 47 .4 | −2 .13 | −3 .0 | 4 | — |

Then the following normal-places were formed:

| No. | $t$—light time 1941 | $\alpha_{1950.0}$ | $\delta_{1950.0}$ | O − C $\Delta\alpha\cos\delta$ | O − C $\Delta\delta$ | $\sqrt{p}$ | Observations |
|---|---|---|---|---|---|---|---|
| I | July 23.96660 | $20^h\ 7^m18^s.61$ | $-6°\ 8'55''.3$ | $-0^s.54$ | $+13''.0$ | 2.0 | 1— 6 |
| II | Aug. 21.70963 | 20 49 8 .89 | −4 54 50 .1 | −0 .13 | −2 .8 | 6.3 | 7—18 |
| III | 28.67058 | 20 59 17 .77 | −5 9 19 .7 | −0 .17 | −0 .4 | 5.1 | 19—27 |
| IV | Sept. 10.44429 | 21 18 15 .06 | −5 40 27 .4 | −0 .25 | −0 .9 | 3.3 | 28—34 |
| V | 18.00066 | 21 29 38 .49 | −5 54 20 .5 | −0 .24 | +1 .9 | 3.9 | 35—41 |
| VI | 23.96431 | 21 38 44 .57 | −6 0 31 .6 | −0 .53 | +0 .8 | 5.4 | 42—52 |
| VII | Oct. 14.26302 | 22 10 29 .49 | −5 40 51 .4 | −1 .91 | −2 .8 | 2.8 | 53—54 |

and the equations of condition were found to be:

$$+19.8224dM_0 + 41.0626d\mu + 0.51675de - 0.04082dp + 1.01137dq + 4.31135dr = -8''.1$$
$$+15.7863 + 313.934 + 4.02330 - 0.45481 + 0.94913 + 3.55031 = -2\ .0$$
$$+14.3172 + 346.377 + 4.43659 - 0.52502 + 0.87727 + 3.27142 = -2\ .6$$
$$+11.6652 + 375.150 + 4.79515 - 0.61045 + 0.72435 + 2.76488 = -3\ .8$$
$$+10.23307 + 377.840 + 4.82050 - 0.63687 + 0.63137 + 2.48949 = -3\ .6$$
$$+\ 9.20276 + 374.803 + 4.77272 - 0.64718 + 0.56032 + 2.29043 = -8\ .0$$

| | | | | | | |
|---|---|---|---|---|---|---|
| + 6.40185 | + 346.345 | + 4.36920 | — 0.63363 | + 0.34979 | + 1.74653 | = —28 .7 |
| + 4.57092 | + 186.914 | + 2.11522 | + 0.17072 | — 4.22992 | + 1.00660 | = +13 .0 |
| + 4.69369 | + 225.102 | + 2.65361 | + 1.55773 | — 3.25082 | + 1.15823 | = — 2 .8 |
| + 4.44765 | + 218.084 | + 2.59019 | + 1.73256 | — 2.89496 | + 1.12026 | = — 0 .4 |
| + 3.86734 | + 198.156 | + 2.38399 | + 1.89444 | — 2.24793 | + 1.00705 | = — 0 .9 |
| + 3.49852 | + 184.847 | + 2.23945 | + 1.91311 | — 1.89657 | + 0.92817 | = + 1 .9 |
| + 3.21337 | + 174.481 | + 2.12452 | + 1.89822 | — 1.64344 | + 0.86535 | = + 0 .8 |
| + 2.36517 | + 143.986 | + 1.77517 | + 1.73495 | — 0.95776 | + 0.67534 | = — 2 .8 |

In solving this system I obtained the result:

$$\begin{aligned} dM_0 &= - \quad 9''.342 \\ d\mu &= - \quad 8.4836 \\ de &= + 661.46 \\ dp &= - \quad 7.05 \\ dq &= - \quad 44.94 \\ dr &= + \quad 52.63 \end{aligned}$$

and the new elements:

$$\left.\begin{array}{l} \text{Osculation 1941 Aug. 29.0 U.T.} \\ T = 1941 \text{ July } 21.20200 \text{ U.T.} \\ \left.\begin{array}{l} \omega = 69°17'\ 2''.0 \\ \Omega = 229\ 39\ 2\ .9 \\ i = 3\ 15\ 26\ .5 \end{array}\right\} 1950.0 \\ e = 0.5821638 \\ \mu = 0°.17864235 \\ a = 3.1223369 \end{array}\right\} \text{II}$$

Although the substitution of the improvements in the equations of condition were in good accordance with the normal-places this did not apply to the direct computation from the new elements, as the improvements were too great. The new residuals were:

| | O — C | |
|---|---|---|
| No. | $\Delta\alpha \cos\delta$ | $\Delta\delta$ |
| I..... | + 0$^s$.17 | + 4″.8 |
| II..... | + 0 .59 | + 5 .5 |
| III..... | + 0 .55 | + 7 .0 |
| IV..... | + 0 .63 | + 3 .9 |
| V..... | + 0 .82 | + 5 .7 |
| VI..... | + 0 .76 | + 4 .4 |
| VII..... | + 0 .68 | + 4 .1 |

Therefore I computed the following new equations of condition from the elements II:

| | | | | | | |
|---|---|---|---|---|---|---|
| + 19.98787$dM_0$ | + 41.1398$d\mu$ | + 0.51493$de$ | − 0.04044$dp$ | + 1.00704$dq$ | + 4.29344$dr$ | = + 2″.4 |
| + 15.93193 | + 316.770 | + 4.03241 | − 0.45270 | + 0.94600 | + 3.53893 | = + 8 .9 |
| + 14.45154 | + 349.583 | + 4.44802 | − 0.52274 | + 0.87456 | + 3.26146 | = + 8 .3 |
| + 11.77827 | + 378.797 | + 4.80981 | − 0.60802 | + 0.72250 | + 2.75767 | = + 9 .5 |
| + 10.33399 | + 381.586 | + 4.83633 | − 0.63447 | + 0.62995 | + 2.48351 | = +12 .3 |
| + 9.29457 | + 378.589 | + 4.78933 | − 0.64484 | + 0.55924 | + 2.28537 | = +11 .4 |
| + 6.46903 | + 350.152 | + 4.38825 | − 0.63164 | + 0.34962 | + 1.74401 | = +10 .2 |
| + 4.60872 | + 188.335 | + 2.12035 | + 0.16916 | − 4.21253 | + 1.00231 | = + 4 .8 |
| + 4.73383 | + 226.981 | + 2.66001 | + 1.55099 | − 3.24107 | + 1.15390 | = + 5 .5 |
| + 4.48611 | + 219.919 | + 2.59658 | + 1.72556 | − 2.88689 | + 1.11621 | = + 7 .0 |
| + 3.90173 | + 199.885 | + 2.39038 | + 1.88755 | − 2.24296 | + 1.00376 | = + 3 .9 |
| + 3.53017 | + 186.466 | + 2.24546 | + 1.90662 | − 1.89304 | + 0.92527 | = + 5 .7 |
| + 3.24289 | + 176.039 | + 2.13050 | + 1.89177 | − 1.64065 | + 0.86281 | = + 4 .4 |
| + 2.38812 | + 145.364 | + 1.78105 | + 1.73030 | − 0.95775 | + 0.67376 | = + 4 .1 |

These gave the new improvements and elements:

$$
\begin{aligned}
dM_0 &= - \ 3''.647 \\
d\mu &= - \ 0 \ .1432 \\
de &= + 12 \ .35 \\
dp &= - \ 0 \ .91 \\
dq &= - \ 1 \ .17 \\
dr &= + 17 \ .73
\end{aligned}
$$

Osculation 1941 Aug. 29.0 U.T.
$T = 1941$ July 21.20767 U.T.
$\omega = 69°17'41''.3$
$\Omega = 229\ 38\ 41\ .2$ } 1950.0
$i = 3\ 15\ 27\ .3$
$e = 0.5822237$
$a = 3.1228007$
$\mu = 0°.17860256$
$P = 5^{y}.519$

III

Hence we get the following residuals between the elements III and the normal-places:

| | O — C | | | |
|---|---|---|---|---|
| | Differentially | | Direct | |
| No. | $\Delta\alpha \cos\delta$ | $\Delta\delta$ | $\Delta\alpha \cos\delta$ | $\Delta\delta$ |
| I | — 0″.1 | — 0″.2 | — 0″.6 | — 0″.2 |
| II | + 0 .5 | — 0 .4 | + 0 .6 | — 0 .4 |
| III | — 0 .9 | + 1 .2 | — 1 .2 | + 1 .2 |
| IV | — 1 .3 | — 1 .5 | — 1 .2 | — 1 .4 |
| V | + 1 .1 | + 0 .7 | + 1 .0 | + 0 .8 |
| VI | — 0 .1 | — 0 .4 | — 0 .1 | — 0 .4 |
| VII | — 1 .3 | + 0 .1 | — 1 .3 | + 0 .1 |

An ephemeris for the opposition in 1946—47 will be published later.

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