1929MNRAS..89..556C

The Perturbations of Comet Pons-Coggia-Winnecke-Forbes from 1818 *to* 1928. By A. C. D. Crommelin.

The comet discovered by Mr. A. F. I. Forbes at Capetown on 1928 November 19* proved to be identical with comet 1818 I (Pons) and 1873 VII (Coggia-Winnecke). The identity of these two had already been suspected by F. Argelander (*A.N.*, **82**, 381), E. Weiss (*A.N.*, **87**, 122), and L. Schulhof (*B.A.*, **3**, 125, 173, 265), but it could not at that time be definitely established owing to the shortness of the arcs of observation, which were 4 days in 1818 and 5 days in 1873; also, assuming identity, it was quite uncertain how many revolutions the comet had made between the two apparitions. Fortunately it was observed for a month in 1928, which has enabled the period to be deduced as about 28 years, so that it has completed four revolutions since 1818. It is the only comet, except Halley's, outside the Jupiter and Saturn groups that has been observed at three apparitions, and it is of interest to examine whether planetary perturbations will explain the inequality in the intervals, which are 55 years 10 months and 54 years 11 months respectively. It was for this purpose that I undertook the following researches. I give for reference the approximate elements at the three apparitions, which, for convenience, I have reduced to the equinox of 1873. We shall see later that the observations of 1818 were too rough to enable good elements to be deduced from them; those given are by Schulhof. Schulhof gave a series of different elements for the 1873 apparition, but I only give the ones corresponding to the period 27·91 years. Those for 1928 III are by H. E. Wood.

Comet.	T.	ω.	Ω.	*i*.	log *q*.	Period.
		° ′	° ′	° ′		y
1818 I Pons	Feb. 4·66	195 18	250 29	25 39	9·87592	9·375
1873 VII {Coggia / Winnecke}	Dec. 1·93273	196 7·6	249 48·7	28 48·0	9·87330	27·910
1928 III Forbes	Nov. 4·493	195 53·9	249 22·5	28 54·8	9·87216	28·655

T is given in G.M.T. (Old Style).

The investigation of the perturbations was made on the lines of my paper in *Memoirs*, vol. lxiv, but as the eccentricity 0·91838 falls outside the limits given there, it was necessary to calculate the coefficients I to X.

The interval of M was taken as 9°, which corresponds to about 250 days in a period of 28 years; this is too large to justify the expectation of very high precision in the results, but it suffices to establish the fact that the perturbations both in the period and in the other elements are very close to those required for identity. The computation is simplified by the fact that there have been no very close approaches to planets during the whole period. The following are the minimum distances in

* It was also glimpsed by Mr. Yamasaki at Misusawa Observatory on 1928 October 26.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1929MNRAS..89..556C

astronomical units, with the approximate dates. Jupiter, 5·1 in 1818, 4·8 in 1843, 4·5 in 1846, 2·6 in 1875, 4·9 in 1901, 4·9 in 1926, 4·4 in 1928. Saturn, 2·9 in 1842, 3·7 in 1870, 6·0 in 1898, 8·1 in 1927. Uranus, 10 in 1824, $9\frac{1}{2}$ in 1907. Neptune, $17\frac{1}{2}$ in 1830. It may be of use to other computers to tabulate the values of v, $\log \frac{r}{a}$, and the logarithms of the coefficients I to X, which include the logarithm of Jupiter's mass. The numerical values are the same for argument 360° − M, the signs being reversed in columns marked R.

M.	v. R.	$\log \frac{r}{a}$.	log I. R.	log II.	log III. R.	log IV.
0°	0° 0′	8·9117	..	0·8048	..	1·7915
9	130 34	9·5896	1·3634	1·2959*n*	1·3711	9·6754
18	144 50	9·7980	1·4516	1·6037*n*	1·2509	1·1060*n*
27	151 42	9·9128	1·4818	1·7507*n*	1·1663	1·3246*n*
36	156 8	9·9902	1·4904	1·8445*n*	1·0975	1·4399*n*
45	159 23	0·0473	1·4870	1·9118*n*	1·0370	1·5163*n*
54	161 58	0·0919	1·4757	1·9631*n*	0·9811	1·5723*n*
63	164 7	0·1277	1·4581	2·0039*n*	0·9278	1·6155*n*
72	165 58	0·1571	1·4351	2·0370*n*	0·8754	1·6502*n*
81	167 35	0·1816	1·4069	2·0644*n*	0·8227	1·6785*n*
90	169 4	0·2021	1·3735	2·0873*n*	0·7686	1·7019*n*
99	170 24	0·2195	1·3344	2·1065*n*	0·7122	1·7215*n*
108	171 40	0·2341	1·2887	2·1226*n*	0·6519	1·7378*n*
117	172 50	0·2464	1·2353	2·1361*n*	0·5863	1·7514*n*
126	173 57	0·2566	1·1722	2·1473*n*	0·5129	1·7626*n*
135	175 2	0·2649	1·0961	2·1564*n*	0·4284	1·7718*n*
144	176 4	0·2715	1·0016	2·1637*n*	0·3273	1·7791*n*
153	177 4	0·2766	0·8785	2·1692*n*	0·1992	1·7846*n*
162	178 3	0·2801	0·7037	2·1730*n*	0·0209	1·7884*n*
171	179 2	0·2822	0·4033	2·1753*n*	9·7184	1·7907*n*
180	180 0	0·2829	..	2·1761*n*	..	1·7915*n*

M.	log V.	log VI. R.	log VII.	log IX. R.	log X.
0°	1·1247	..	9·3506	..	1·8493*n*
9	0·9379*n*	1·5473	1·4390*n*	1·4101*n*	1·1714*n*
18	1·0372*n*	1·5852	1·6352*n*	1·2898*n*	0·9629*n*
27	1·0695*n*	1·5948	1·7424*n*	1·2052*n*	0·8482*n*
36	1·0859*n*	1·5918	1·8150*n*	1·1364*n*	0·7708*n*
45	1·0960*n*	1·5811	1·8688*n*	1·0760*n*	0·7137*n*

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

M.	log V.	log VI. R.	log VII.	log IX. R.	log X.
54°	1·1029*n*	1·5645	1·9109*n*	1·0201*n*	0·6691*n*
63	1·1078*n*	1·5430	1·9449*n*	0·9668*n*	0·6333*n*
72	1·1116*n*	1·5170	1·9729*n*	0·9143*n*	0·6039*n*
81	1·1145*n*	1·4865	1·9962*n*	0·8616*n*	0·5794*n*
90	1·1168*n*	1·4512	2·0159*n*	0·8076*n*	0·5589*n*
99	1·1186*n*	1·4105	2·0324*n*	0·7511*n*	0·5415*n*
108	1·1201*n*	1·3637	2·0465*n*	0·6909*n*	0·5269*n*
117	1·1213*n*	1·3092	2·0582*n*	0·6252*n*	0·5146*n*
126	1·1223*n*	1·2453	2·0680*n*	0·5518*n*	0·5044*n*
135	1·1231*n*	1·1685	2·0760*n*	0·4674*n*	0·4961*n*
144	1·1237*n*	1·0735	2·0823*n*	0·3663*n*	0·4895*n*
153	1·1242*n*	0·9500	2·0872*n*	0·2382*n*	0·4844*n*
162	1·1245*n*	0·7750	2·0906*n*	0·0598*n*	0·4809*n*
171	1·1247*n*	0·4744	2·0926*n*	9·7573*n*	0·4788*n*
180	1·1247*n*	..	2·0933*n*	..	0·4781*n*

log VIII=log VI+9·5973*n*.

Since the value of *n* at any moment is unknown at the start, the perturbations in the first two revolutions were computed using the period 27·91 years, which is half the interval between the perihelia of 1818 and 1873; those in the other two revolutions with the period 27·46 years. The following tables give the perturbations thus found for the different elements.

	Perturbations of ω.				Perturbations of Ω.			
	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4.	Rev. 1.	Rev. 2.	Rev. 3.	Rev.
Jupiter	− 264″·0	+247″·6	−553″·8	−191″·8	− 481″·0	+333″·3	− 900″·9	−62
Saturn	+1013·8	+461·1	+120·8	+ 36·6	−1033·0	−370·3	− 153·9	−12
Uranus	+ 9·7	+ 2·5	+ 2·4	+ 15·0	− 4·6	− 1·2	+ 0·6	−
Neptune	+ 12·2	− 2·5	+ 1·3	+ 3·3	− 11·9	+ 2·1	− 0·4	−
Sum.	+ 771·7	+708·7	−429·3	−136·9	−1530·5	− 36·1	−1054·6	−76

	Perturbations of *i*.				Perturbations of φ.			
	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4.	Rev. 1.	Rev. 2.	Rev. 3.	Rev
Jupiter	− 322″·1	− 13″·5	+915″·6	−403″·5	+ 8″·3	+ 10″·2	−57″·8	+1
Saturn	− 701·9	−242·6	− 91·5	− 43·2	+123·3	+ 91·5	+12·3	+
Uranus	− 20·8	+ 0·6	− 4·3	− 28·9	− 13·1	+ 4·0	− 0·3	−1
Neptune	− 18·5	+ 3·2	+ 1·8	− 4·5	− 10·4	+ 2·3	+ 2·4	−
Sum.	−1063·3	−252·3	+821·6	−480·1	+108·1	+108·0	−43·4	−

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1929MNRAS..89..556C

1929MNRAS..89..556C

	Perturbations of M_0.				Perturbations of n.			
	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4.	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4.
	″	″	″	″	″	″	″	″
Jupiter	+2045·1	+1697·5	+2757·5	+2042·0	−1·3958	+0·3858	+2·5286	−1·6774
Saturn	+ 249·6	− 67·3	− 131·7	− 161·1	−0·1351	+0·0213	−0·0327	−0·0119
Uranus	+ 18·3	− 20·8	+ 21·5	+ 14·6	−0·0089	+0·0021	−0·0013	−0·0116
Neptune	− 8·5	+ 5·5	− 7·7	− 6·4	−0·0039	+0·0009	+0·0009	−0·0012
Sum.	+2304·5	+1614·9	+2639·6	+1889·1	−1·5437	+0·4100	+2·4955	−1·7021

	Perturbations of n (Second Summation).				Second Summation, combining two Revolutions.	
	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4.	Revs. 1 and 2.	Revs. 3 and 4.
	″	″	″	″	″	″
Jupiter	+368·1	−2016·5	+27308·5	−721·7	−15863·2	+51946·8
Saturn	−835·1	− 252·8	+ 120·7	+526·6	− 2467·9	+ 320·0
Uranus	− 61·9	+ 1·7	− 7·2	− 82·9	− 150·9	− 103·5
Neptune	− 28·4	+ 8·0	+ 0·3	− 9·7	− 60·5	− 0·4
Sum.	−557·3	−2259·6	+27422·3	−287·7	−18542·5	+52162·9

Hence the total perturbation of M, which is found by adding the perturbation of M_0 to the result of the second summation of the perturbation of n, is − 14623″·1 for revolutions 1 and 2, and + 56691″·6 for revolutions 3 and 4.

It will save time to anticipate here the result of a re-examination of the observations of 1818, which indicates 1818 February 6·52 as a closer approximation to the date of perihelion than that given above (a still later value is February 6·30, but as it is uncertain by 0·25 it is unnecessary to change the figure).

The Julian days for the three perihelia are 2385107·52, 2405494·933, 2425555·493. From the first two, starting from perihelion in 1818, we have the equation

$$0 + n_{1818} \times 20387{\cdot}41 - 14623''{\cdot}1 = 2592000''.$$

The right-hand side is twice the number of seconds in the circumference. We thus obtain $n_{1818} = 127''{\cdot}8546$; period 1818 = $27^{y}{\cdot}7518$. Applying the perturbation in n, we find $n_{1873} = 126''{\cdot}7209$; period 1873 = $28^{y}{\cdot}0000$.

From the second two perihelia we obtain the equation

$$0 + n_{1873} \times 20060{\cdot}56 + 56691''{\cdot}6 = 2592000''.$$

We find $n_{1873} = 126''{\cdot}3827$; period 1873 = $28^{y}{\cdot}0749$; hence $n_{1928} = 127''{\cdot}1761$; period 1928 = $27^{y}{\cdot}8998$.

There is thus a discordance of $0^{y}{\cdot}0749$, or $27\frac{1}{3}$ days, between the two values found for the period in 1873. On examination I was led to ascribe this to the fact that the initial assumption of uniform period from 1818 to 1873, and from 1873 to 1928, gave erroneous times for the intermediate perihelion passages; hence the Jupiter and Saturn perturbations about these times need revision. I found that the 1846

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

perihelion was more affected in this way than the 1901 one. I provisionally adopted $28^{y}\cdot05$ as the period in 1873, and deduced the perihelion dates 1845 October 5 and 1901 April 26. These are respectively 90 and 23 days earlier than those used in the first calculation. (The revised calculation gives the dates of perihelion 1845 October 18 and 1901 May 7.) The perturbations by Jupiter and Saturn have been recalculated from the aphelion of 1831 to that of 1859, and those by Jupiter from the aphelion of 1887 to that of 1915.

The following table gives the revised values: revision was considered unnecessary for Uranus and Neptune, or for Saturn in the second pair of revolutions.

	Perturbations of ω.				Perturbations of Ω.			
	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4.	Rev. 1.	Rev. 2.	Rev. 3.	Rev.
	″	″	″	″	″	″	″	
Jupiter	−227·2	+251·0	−554·7	−194·2	− 625·3	+336·5	− 905·6	−632
Saturn	+978·4	+458·1			− 953·7	−368·8		
Sum. of 4 planets	+773·1	+709·1	−430·2	−139·3	−1595·5	− 31·4	−1059·3	−770

	Perturbations of i.				Perturbations of ϕ.			
	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4.	Rev. 1.	Rev. 2.	Rev. 3.	Rev.
	″	″	″	″	″	″	″	
Jupiter	− 353·9	− 1·2	+913·0	−408·4	+ 50·1	+ 24·6	−78·4	+18
Saturn	− 648·7	−233·8			+128·7	+ 96·3		
Sum. of 4 planets	−1041·9	−231·2	+819·0	−485·0	+155·3	+127·2	−64·0	+ 5

	Perturbations of M_0.				Perturbations of n.			
	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4.	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4
	″	″	″	″	″	″	″	″
Jupiter	+2083·6	+1763·9	+2799·9	+2040·9	−1·5655	+0·3225	+2·5331	−1·65
Saturn	+ 182·3	− 61·1			−0·0933	−0·0777		
Sum. of 4 planets	+2275·7	+1687·5	+2682·0	+1888·0	−1·6716	+0·2478	+2·5000	−1·67

	Perturbations of n (Second Summation).				Second Summation, combining two Revolutions.	
	Rev. 1.	Rev. 2.	Rev. 3.	Rev. 4.	Revs. 1 and 2.	Revs. 3 and 4
	″	″	″	″	″	″
Jupiter	+220·0	−2677·6	+27276·5	−471·7	−18303·3	+52212·8
Saturn	−782·0	− 340·7			− 2075·0	
Sum. of 4 planets	−652·3	−3008·6	+27390·3	− 37·7	−20589·7	+52428·9

The first two revolutions give us, in the same manner as before, $n_{1818} = 127''\cdot9525$, $n_{1873} = 126''\cdot5287$; period 1818 = $27^{y}\cdot7305$, period 1873 = $28^{y}\cdot0426$.

The last two revolutions give $n_{1873} = 126''\cdot3677$, $n_{1928} = 127''\cdot1894$; period 1873 = $28^{y}\cdot0783$, period 1928 = $27^{y}\cdot8969$.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1929MNRAS..89..556C

1929MNRAS..89..556C

The discordance between the two determinations of the period in 1873 has now been reduced to $0^{y} \cdot 0357$, or 13 days. It is presumably due to the 250-day interval employed in the perturbations being too long. It would have been better to have used intervals of 9° of *eccentric anomaly*, instead of 9° of *mean anomaly*; but I did not notice this till it was too late to retrace my steps.

It is worth noting that the unperturbed discordance is $5\frac{1}{2}$ months *in the other direction*, so that the calculation has over-explained it in the proportion of 14 to 13.

I pass now to the discussion of Pons's observations in 1818, and a comparison between them and the positions computed from the following assumed orbit, which I deduced by applying the perturbations found above to L. Schulhof's elements for 1873.

$$\left.\begin{array}{rl} \omega & 195^\circ\ 43'\cdot 8 \\ \Omega & 249\ \ 29\cdot 1 \\ i & 29\ \ \ 9\cdot 5 \end{array}\right\} 1818\cdot 0.$$

$$\begin{array}{rl} \phi & 66\ \ 43\cdot 2 \\ \log q & 9\cdot 87265 \\ \text{Period} & 27^{y}\cdot 731 \end{array}$$

Gaussian equations:

$$\begin{aligned} x &= [9\cdot 94931]\, r \sin (v + 172^\circ\ 32'\cdot 2) \\ y &= [9\cdot 99192]\, r \sin (v + \ \ 76\ 48\cdot 4) \\ z &= [9\cdot 69434]\, r \sin (v + 146\ 48\cdot 7) \end{aligned}$$

T is left to be determined from the observations. The value finally adopted is 1818 February 6·30 G.M.T.

As rectangular co-ordinates of the Sun were not given in the Almanacs at that epoch, it is convenient to give the values that I have computed from the data of the *Berliner Jahrbuch*. The observations are so rough that a determination from modern tables is not called for.

Pons gave his time of observation as 7^{h} Marseilles time; making a preliminary estimate of the light-time as $6^{m} \cdot 3$, I made the computations for $6^{h}\ 34^{m} \cdot 3$ G.M.T.

G.M.T.	log X.	log Y.	log Z.
1818 Feb. 23·274	9·95156	9·59047*n*	9·22806*n*
24·274	9·95521	9·57417*n*	9·21176*n*
25·274	9·95869	9·55709*n*	9·19468*n*
26·274	9·96200	9·53915*n*	9·17673*n*
27·274	9·96517	9·52032*n*	9·15792*n*

Herr Oberhofmeister Freiherr von Zach published in *Zeitschrift für Astronomie*, Jan. und Feb. 1818, p. 150, the following extract from a letter received by him from J. L. Pons, dated 1818 February 28. I think it well to reproduce this *in extenso*, as it is the sole source of information concerning the apparition of our comet in 1818.

"Am 23 Febr. entdekte Herr *Pons*, Abends um 7 Uhr abermals einen Cometen auf der Brust des Wallfisches in 15° 15′ südlicher

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1929MNRAS..89..556C

Abweichung; er beschreibt ihn also: 'Dieser Comet ist beinahe eben so klein, als der vorhergehende, man sieht ihn nicht mit blosen Augen, und er verträgt keine Beleuchtung. Er hat weder Schweif noch Bart. Sein Mittelpunct ist etwas heller, der Nebel wenig ausgedehnt. Am 24 Febr. sah ich ihn nur auf wenige Augenblicke, wegen des schlechten Wetters, ich habe jedoch so viel erkannt, dass er eine ziemlich schnelle Bewegung in gerader Aufsteigung hat, etwa 7 Minuten in Zeit gegen Osten, und 40 Min. in Abweichung gegen Süden. Den 26 Febr. gieng er ungefehr 3 Minuten nach einem Stern 4 Grösse durchs Feld des parallactischen Fernrohrs. Dieser Stern ist der südlichste von den vier Sternen, welche auf der Brust des Wallfisches ein Viereck bilden. Den 27 Febr. war der Comet im Felde des Fernrohrs mit einem Stern unter den Pfoten des Wallfisches, etwa 50 Min. östlicher. Es ist ungefehr 14 Tage, dass ich einen schwachen Nebelfleck etliche Grade unter dem Stern *B* im Wallfisch bemerkt hatte, welchen mir böses Wetter wieder zu sehen verhindert hatte, ich vermuthe beinahe, dass diess der Comet gewesen sei. Vermög seines Laufes, wird er sich nun bald unter dem Horizonte verlieren.'

Aus allen diesen Datis erhellet, dass der Comet am 26 Febr. mit dem Stern σ, den 27 Febr. mit τ im Wallfisch verglichen worden ist. Hieraus lassen sich zwar keine sichere Stellungen herleiten, indessen gebe ich hier folgende Conjecturen, aus welchen man wenigstens wird erkennen können, ob es derselbe Comet ist, im Falle er irgendwo beobachtet worden wäre.

1818 Febr. 23,	7 Uhr M.,	A. R. Comet $31^\circ\ 15'$,	Abw. $15^\circ\ 15'$	südl.
24	,,	,, 33 0	16 55	südl.
26	,,	,, 36 30	17 35	südl.
27	,,	,, 36 18	18 15	südl."

With regard to the estimates of position by von Zach, it would appear that he intended to use Pons's statement of daily motion + 1° 45′, south 40′. There are, however, some slips: this supposition would give R.A. on February 27, 38° 15′, and Decl. on February 24, 26, 27, 15° 55′, 17° 15′, 17° 55′ respectively. It is probable that Pons gave the Decl. on February 23 simply as 15° south, and that von Zach inserted the 15′ as correction for index error and refraction (see his previous communication on p. 149 of the *Zeitschrift*, where he states that the index reading is $11\frac{1}{2}'$ too far north).

The star that von Zach erroneously calls τ Ceti is Flamsteed's 90 Ceti,* now known as τ^1 Eridani. The following are the positions of stars for 1818·0:—

Star.	Mag.	R.A. 1818·0.	S. Decl. 1818·0.
		h m s	° ′
β Ceti	2·2	0 34 27·3	18 59·2
σ Ceti	4·8	2 23 27·88	16 2·9
Lalande 4976	6·9	2 31 27·1	17 5·8
τ^1 Eridani	4·6	2 36 36·69	19 20·9

* Erroneously designated 80 Ceti in Boss P.G.C.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1929MNRAS..89..556C

I insert Lalande 4976, since it seems to me possible that this was the star used by Pons on February 27: it was nearer to the comet in declination than τ^1 Eridani; also the comet was to the *east* of it, whereas it was to the *west* of τ^1.

We deduce $2^h\ 26^m\ 27^s{\cdot}88$ or $36°\ 36'{\cdot}97$ for the observed R.A. of the comet on February 26. I take it that the 50′ on February 27 is to be reckoned in great circle, since it was apparently estimated by distance in the field of view, not by transits. We deduce that the observed R.A. on February 27 was 38° 44′·29 if Lal. 4976 was the star used, 38° 16′·53 if it was τ^1 Eridani. I have constructed the following ephemerides on two assumptions of the date of perihelion.

T 1818 Feb. 6·921 G.M.T.

1818 G.M.T.	R.A.	S. Decl.	log *r*.	log Δ.
	° ′	° ′		
Feb. 23·2724	31 24·96	13 46·89	9·90752	9·84809
24·2724	32 59·93	14 25·73	9·91151	9·84498
25·2724	34 35·22	15 3·64	9·91559	9·84217
26·2724	36 12·04	15 42·28	9·91985	9·83944
27·2724	37 49·54	16 20·36	9·92422	9·83697

T 1818 Feb. 5·921 G.M.T.

1818 G.M.T.	R.A.	S. Decl.	log *r*.	log Δ.
Feb. 23·2724	32 18·73	15 13·44	9·91151	9·83744
24·2724	33 54·48	15 52·62	9·91559	9·83464
25·2724	35 31·50	16 32·63	9·91985	9·83191
26·2724	37 9·62	17 11·91	9·92422	9·82944
27·2724	38 48·00	17 50·53	9·92867	9·82722

By interpolation we find that T = February 5·903 from the declination on February 23, February 6·488 from the R.A. on February 26, February 5·984 from the R.A. on February 27 using Lalande, February 6·459 from that R.A. using τ^1. I assign weights 2, 4, 1, 2 to these. The highest weight is given to the R.A. from σ Ceti, since there is no doubt about the identity of the star in this case. The weighted mean is February 6·296, which is unlikely to be more than 0·25 days in error. The average daily motion was 1° 36′·9, south 39′·0; Pons's estimate of 1° 45′, south 40′, was tolerably good. The computers of the orbit gave great weight to this estimate, which explains the fact that fair orbits were deduced from such unsatisfactory material.

In view of Pons's statement about an object seen a fortnight earlier, I calculated the following positions (from slightly different elements).

	R.A.	S. Decl.	log Δ.
	h m s	° ′	
1818 Feb. 14·2	1 13 52	8 23	9·8802
15·2	1 19 44	8 58	9·8761

These show that the comet was fully 10° to the north of β Ceti,

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1929MNRAS..89..556C

which I assume to be the object meant by *B* Ceti. Hence the object seen a fortnight earlier was not this comet.

It is of interest to compare the perturbations calculated for ω, Ω, and i from 1873 to 1928 with the changes shown by the orbits given above: they are as follows:—

	Calculated.	Observed.
	′	′
ω	− 9·5	−13·7
Ω	−30·5	−26·2
i	+ 5·6	+ 6·8

It will be noticed that the orbit given for 1928 is not definitive, and that the change of the period from $28^{y}·655$ to $27^{y}·89$ would have some effect on the other elements. The agreement is as close as we could expect.

I have not applied perturbations by the Earth or Venus; the closest approach to the Earth was at the 1873 perihelion when the least distance was 0·219 (very nearly the least possible value). In 1818 it was about 0·6, in 1928 0·47; the distances in 1845 and 1901 were greater. Venus can make close approaches to the comet, the distance between the orbits near the comet's descending node being only about 0·04. For such an approach the longitude of Venus would have to be 69°·8 eight days before the comet's perihelion passage, or 83° at the perihelion passage. The actual longitudes of Venus at the different perihelia were 1818 300°, 1845 305°, 1873 201°, 1901 49°, 1928 301°. The approach to the earth in 1873 appears to be the only one that would be likely to give appreciable perturbations.

There are some fairly close commensurabilities between the comet's period and those of the large planets. Thus seven periods of Jupiter are equal to 83·03 years, which happens to be exactly the interval between the comet's perihelion passages in 1845 and 1928. Also six periods of the comet are very close to Neptune's period, and three periods to that of Uranus. In view of the smallness of the perturbations due to these planets, it will suffice for most purposes to take them as repeating themselves after these periods.

The period of the comet is fairly close to that of Saturn, so the conditions change rather slowly from revolution to revolution. The comet is at Saturn's distance from the Sun $3\frac{1}{2}$ years before and after perihelion. The following table shows the values of $L_1 - u$ and B_1 in the different revolutions, and the distance of the comet from Saturn.

Perihelion.	Before Perihelion.			After Perihelion.		
	$L_1 - u$.	B_1.	Dist.	$L_1 - u$.	B_1.	Dist.
	°	°		°	°	
1818	..	..	..	140·7	−23·5	18
1845	350·0	−13·2	3	116·8	−29·2	17
1873	337·2	− 6·2	4	98·0	−30·7	15
1901	318·6	+ 4·8	7	71·4	−28·0	12
1928	298·8	+15·5	10			

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1929MNRAS..89..556C

The perturbations before perihelion reached a maximum about 1845; those after perihelion will reach a maximum about three revolutions after 1928.

We can make a fair estimate of the date of perihelion in 1956 by using the above relations. The following are the estimated perturbations:—

	M_0.	*n*.	*n* (second sum.).
Jupiter	+1764″	+·3225″	−2678″
Saturn	− 190	0	+ 700
Uranus	− 21	+·0021	+ 2
Neptune	− 5	−·0015	− 13
Sum.	+1548	+·3231	−1989

I assume $27^y·89$ for the period in 1928, which makes $n = 127''·221$. Then $n_{1928} \times$ interval in days $- 441'' = 1296000''$.

This gives 10,190 days and makes the estimated perihelion passage 1956 September 29, the period then being $27^y·82$. It will be a less favourable return than the recent one, but the comet should be observable without difficulty. The longitude of Venus will be about 69°, so there is likely to be a much closer approach to that planet than at any time since 1818.

In conclusion I quote Toscanelli's observations of comet 1457 I, as given by L. Schulhof in *B.A.*, **3**, 134; there is good reason for suspecting that this is the same comet; if so, 13 revolutions were completed between 1457 and 1818, giving a mean period of 27·77 years.

1457 6^h Paris M.T.	Longitude.	Latitude.
Jan. 23	358° 13′·5	− 7° 9′·0
24	359 33·0	− 7 33·0
25	0 26·1	− 8 46·3
26	1 36·0	− 9 39·9
27	2 30·0	−10 29·7

It is obvious from internal evidence that these are liable to errors of at least 15′. Schulhof showed that they could be satisfied by his elements of this comet within quantities of about the same order of magnitude. Celoria deduced the following orbit from these observations before the identity was suggested, so that they are quite independent:—

T 1457 Jan. 18·0, ω 194°·9, Ω 249°·7, i 13°·3, log q 9·847.

The only discordance is in the inclination, and the comet was too near the ecliptic for this to be very accurately deduced from such rough observations.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1929MNRAS..89..556C

Emission Lines on the Absorption Bands of H *and* K.

By J. Evershed, F.R.S.

In *Monthly Notices*, **87**, 350, I recorded the presence of an emission line in the solar spectrum near K, having the approximate wave-length 3934·80 I.A., or 3934·94 on Rowland's scale. I now find that this line was observed thirty years ago by L. E. Jewell, who gives the wave-length 3934·954. Jewell at first thought the line might be a ghost of the reversal of K, but finally concluded that "there is no question whatever as to the chromospheric origin of the line" (*Astrophysical Journal*, **8**, 119, 1898).

The bright line is only found close to the limb of the Sun, and cannot be traced over the disc more than about one-twentieth of the solar radius. In some recent photographs obtained under the best atmospheric conditions, with the slit of the spectrograph so nearly tangent to the limb that the overlap would not exceed 5″, three other bright lines have been detected. In these plates the 3934 line stands out very clearly, whilst a less conspicuous emission line is found on the other side of K nearly twice the distance from its centre. In addition, in the H region there appears to be a strong emission line bordering the iron line λ3969·270 on the red side, and a very faint emission line on the other side of H, and further from its centre. This is difficult to detect on the brighter background except on plates that have been given exactly the right exposure, and which have not overlapped the limb too much. It is sufficiently distinct on one or two of my plates to allow of fairly accurate measurement.

The approximate positions of the four emission lines on my plates, and of the centres of H and K, as given in the recently published Revision of Rowland's "Preliminary Table," are as follows :—

Line.	λ I.A.	Intensity.
Emission 1	3931·54	0
K	3933·684	1000
Emission 2	3934·80	2
Emission 3	3967·04	0
H	3968·494	700
Emission 4	3969·40	3

The wave-lengths of the calcium lines presumably refer to the centres of H_2 and K_2 as observed at the centre of the Sun's disc, whilst the wave-lengths of the emission lines are derived from solar iron lines in the limb spectra. These values are subject to a small positive correction for limb-effect, which would, however, not amount to more than two or three thousandths of an angstrom.

According to the Revised Table of Rowland, an absorption line occurs at 3931·590, intensity 1, but marked as doubtful. This is almost coincident with the emission line No. 1, but does not exist in any of my spectra, either of the limb or of the centre of the disc. Also near

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System