

vollkommen aufrecht. Meine Aeusserung enthält also eine Kritik der objectiven Güte der Campbell'schen Beobachtungen, nicht aber der subjectiven Zuverlässigkeit oder Unzuverlässigkeit des Herrn Campbell selbst. Das erstere ist eine sachliche Kritik, das zweite wäre eine Beleidigung.

In sachlicher Beziehung bedaure ich, Herrn Runge bitten zu müssen, sich meine demnächst in dem *Astrophysical Journal* erscheinende Entgegnung gegen Herrn Campbell anzusehen und deren sachlichen Inhalt nunmehr auch auf sich beziehen zu wollen. Die Entgegnung an dieser Stelle zum Abdruck zu bringen, halte ich nicht für erforderlich; zur Orientirung weise ich nur darauf hin, dass ich selbst trotz, oder vielmehr wegen der günstigeren instrumentellen Beobachtungsbedingungen den Unterschied zwischen den relativen Intensitäten nicht wahrnehme (»soweit so etwas überhaupt erkannt werden kann«), dass ich aber gerne glaube, dass Herr Runge ihn gesehen hat. Hieraus folgt aber dann, dass auch Herr Runge, ebenso wie Herr Campbell, sein »Sehen«

nicht genügend sorgfältig und fein discutirt hat, weil er die Erscheinung sonst nicht für reell sondern nur als verursacht durch das bekannte Purkinje'sche Phänomen gedeutet und vor allem nicht eine Hypothese darauf aufgebaut haben würde. (Siehe den vorstehenden Aufsatz über das Spectrum des Wasserstoffs in den Nebelflecken).

Ich kann mir nicht versagen, darauf hinzuweisen, dass dieselbe physiologische Eigenthümlichkeit unseres Auges auch die unter Nr. 5 von Herrn Runge angeführten Beobachtungen ihrer Realität und damit ihrer physikalischen Bedeutung entkleidet, und dass auch Nr. 3 dadurch eine ungezwungene Erklärung finden könnte, falls man die durch Messungen leider nicht unterstützte Beobachtung für objectiv richtig ansehen will. Uebrigens vermisste ich auch in Betreff der Nr. 4 den für eine autoritative Beobachtung unerlässlichen Nachweis durch die Messung, mit welchem Grade von Sicherheit die von Herrn Runge im Roth gesehene Linie wirklich als die C-Linie anzusehen ist.

Potsdam, Kgl. Observatorium, 1898 Jan. 22.

*J. Scheiner.*

## The Variable Star U Pegasi.\*)

By *Edward C. Pickering.*

Much difficulty has been experienced in determining the nature of the variations in the light of this star. Mr. Chandler states that he at first supposed that it was a star of the Algol type having a period of 2<sup>d</sup>06 or 2<sup>d</sup>07. It was then observed by Mr. Yendell who confirmed the variability and still regarded it as of the Algol type, but with a period of 0<sup>d</sup>69. Mr. Chandler, under date of Oct. 26, 1895, announces in the *Astr. Journal* 15, p. 181, that the period is 5<sup>h</sup>31<sup>m</sup>9<sup>s</sup>0 which »is probably only a moderate fraction of a second in error«, that it is not of the Algol type, but that the times of increase and decrease are equal. Mr. Yendell (*Astr. Journal* 16, p. 78) states that the time of increase varies from 1<sup>h</sup>28<sup>m</sup> to 3<sup>h</sup>41<sup>m</sup>. Again, Mr. Chandler (*Astr. Journal* 16, p. 107) announces that the period is 5<sup>h</sup>32<sup>m</sup>25, that it is perfectly regular, and that previous discrepancies are due to a large subjective error amounting to 0<sup>m</sup>6  $\rho$ , in which  $\rho$  is the parallactic angle. The correction for this error will sometimes increase and sometimes diminish the observed time of minimum by as much as half an hour. He also states that the decrease in light is more rapid than the increase, and, referring to the short period variables  $\eta$  Aquilae and  $\delta$  Cephei, that »we may therefore regard U Pegasi, provisionally, as a type of variability distinct from this class of stars, as it evidently is from those of the Algol type«.

Owing to these uncertainties it seemed desirable to determine the true form of the light curve photometrically, especially as such observations are free from the subjective error mentioned above, since the images compared are constantly interchanged. Assuming the light curve to be constant, it appeared possible to determine its form from observations made during a single evening. Accordingly, measures were made by Mr. O. C. Wendell with the polarizing

photometer (*Astrophys. Journal* II, 89) attached to the 15 inch equatorial telescope of the Harvard College Observatory. The results for a single evening, Dec. 28, 1897, are contained in the annexed table, the first column giving the Greenwich Mean Time, and the second the photometric magnitude found by adding the observed difference in magnitude between U Pegasi and the comparison star, +15<sup>h</sup>49<sup>m</sup>16, to 8.90, the photometric magnitude of the latter star. These observations are also indicated by the crosses in the figure. The third column gives the residuals found by subtracting from the magnitude given in the second column that derived graphically from all the observations.

Observations on Dec. 28, 1897.

G. M. T.	Magn.	O—C	G. M. T.	Magn.	O—C
10 <sup>h</sup> 26 <sup>m</sup> 9	9.63	0.00	13 <sup>h</sup> 48 <sup>m</sup> 7	9.60	—0.01
10 34.2	9.56	—0.01	13 58.6	9.67	—0.02
10 42.2	9.52	+0.01	14 17.5	9.78	+0.04
10 55.3	9.48	+0.02	14 24.5	9.77	+0.02
11 4.7	9.43	+0.02	14 34.0	9.75	+0.02
11 12.4	9.36	—0.02	14 43.0	9.75	+0.07
11 31.3	9.32	—0.01	14 50.0	9.65	0.00
11 40.0	9.33	+0.02	15 7.0	9.56	+0.03
11 48.6	9.30	0.00	15 15.0	9.48	0.00
11 55.4	9.27	—0.02	15 21.0	9.42	—0.02
12 25.8	9.30	0.00	15 26.8	9.42	0.00
12 33.4	9.28	—0.02	15 33.2	9.42	+0.04
12 41.2	9.32	+0.01	15 56.9	9.34	0.00
12 51.1	9.36	+0.03	16 3.0	9.37	+0.02
13 17.4	9.43	+0.01	16 13.3	9.35	+0.01
13 27.2	9.46	—0.01	16 21.2	9.38	+0.04
13 36.0	9.56	+0.03	16 29.6	9.34	0.00

\*) Harvard College Observatory Circular No. 23.

Each observed magnitude is derived from the mean of four sets of four settings each, the photometer being reversed between the second and third sets, and the positions of the images of the stars interchanged after the second setting of each set. The magnitudes derived from each pair of sets differ on the average  $\pm 0.04$  magn. The average values of this quantity during the seven successive hours of observation were 0.06, 0.03, 0.04, 0.03, 0.04, 0.04, and 0.04 respectively. As they show no progressive increase it is evident that the fatigue of the observer did not sensibly affect the accuracy of the observations. The accuracy is also unaffected by the altitude which was only  $5^\circ 6'$  at the end of the series. No correction has yet been applied for differential absorption, which is small but sensible, although the distance between the stars compared is only  $15'$ . The computed probable error of a single set of four settings from these differences is  $\pm 0.024$  magn. The average value of the residuals in the third column is  $\pm 0.017$ , only one being greater than 0.04.

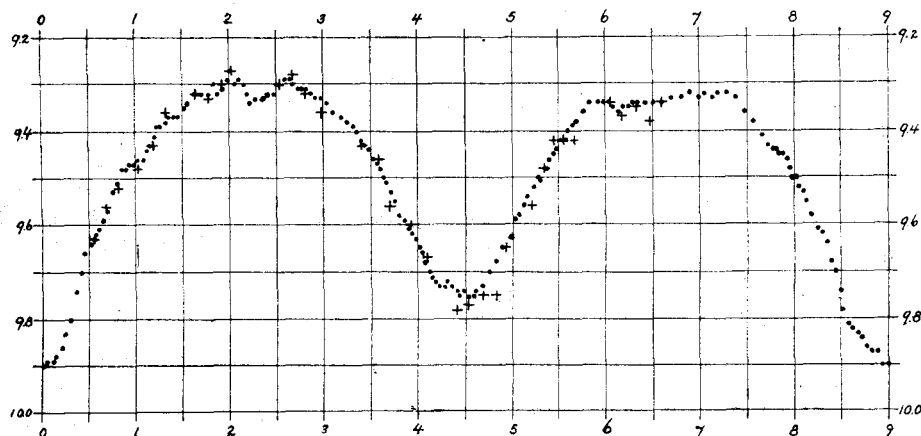
It is obvious from an inspection of these observations that the star had nearly the same brightness after an interval

of  $4^h 30^m$ , at first indicating that the variable had this period and not  $5^h 31^m$ . But later observations showed that the phenomena were not quite so simple. Assuming the period  $4^h 30^m$  it soon appeared that the even minima were fainter than the odd. Observations continued through even minima on four nights gave the minimum brightness of U Pegasi, including errors of observation, 9.94, 9.94, 9.92, and 9.85 respectively, while corresponding measures of odd minima gave the magnitudes 9.78, 9.78, and 9.75. It thus became evident that the period should be doubled, and plotting the observations a light curve was formed closely resembling that of  $\beta$  Lyrae. The formula

$$J. D. 2413514.6157 + 0^d 37478 E$$

has been adopted which closely represents the observations recently made and also a few less accordant observations made here in 1895. Changing the period by two seconds, to  $0^d 3748$ , would alter the times of minima in 1895 by about an hour while the uncertainty is only a small fraction of this amount. The period may, therefore, be assumed to be  $8^h 59^m 41^s$ . The magnitude at maximum is 9.30, at primary minimum 9.90, and at secondary minimum, 9.75.

Photometric Observations.



The above figure represents the observations on a scale such that in the ordinates one division corresponds to a tenth of a magnitude, and in the abscissas to 30 minutes. All the observations made by Mr. Wendell on eight nights are included, none being rejected for discordance. In fact, the most discordant set of sixteen settings differs from the mean curve by less than a tenth of a magnitude. Each dot represents 80 settings, the method of overlapping means, in common use in meteorology, being employed. The observations of Dec. 28, as stated above, are represented by crosses, each representing the result of sixteen settings. The total number of settings was 2784 and the entire time of observation including rests, about 30 hours.

If we neglect the difference between the primary and secondary minima, reduce the half period to fractions of a day, and multiply it by 16 we obtain the product  $2^d 99824$ , or very nearly three days. Therefore, the phases recur at nearly the same times every three days. If we multiply the period  $5^h 32^m 15^s$  by 13 we obtain  $2^d 99948$ , or very nearly

the same quantity. In either case, therefore, the phases would recur at the same times every three days, but with the second period the interval between successive minima would be greater than with the first period in the ratio of 16 to 13. If then we used the second period we should find the observed minima in error by an amount equal to three-thirteenths of the hour angle, or expressed in minutes  $0^m 92 h$ , in which  $h$  is the hour angle expressed in degrees. Since the latitude of Cambridge is  $+42^\circ 4'$  and the declination of U Pegasi is  $+15^\circ 4'$  it follows that when  $h$  is small we may write  $h = 0.61 p$  and  $0^m 92 h = 0^m 56 p$  which agrees very nearly with  $0^m 6 p$  the correction found empirically by Mr. Chandler from his observations. The coefficient becomes larger with large hour angles having the values 0.61, 0.74, and 0.91 for  $h = 15^\circ, 30^\circ$ , and  $45^\circ$ , respectively. It, therefore, follows that by the application of the correction  $0^m 6 p$  not only were the observed times of minima changed in some cases by more than half an hour but an error of more than an hour was introduced into the half period. An

arbitrary correction proportional to the parallactic angle is not to be recommended, since by assuming different values of the coefficient, very different values of the period will be found.

From the above discussion it appears that U Pegasi is no longer the variable star having the shortest period known. This position appears to be held by the variable  $\omega$  Centauri 19, discovered by Professor Bailey who finds

Harvard College Observatory, 1898 Jan. 14.

its period to be  $7^h 11^m$ . Although U Pegasi can no longer be regarded as an example of that peculiar class of short period variables having a single maximum in which the decrease is more rapid than the increase, this class is still represented not only by S Antliae, but by  $\omega$  Centauri 24, which Professor Bailey finds to decrease twice as rapidly as it increases, while  $\omega$  Centauri 45 increases at least five times as fast as it diminishes.

Edward C. Pickering.

## Elemente des Planeten (424) (1896 DF) und Ephemeride für die Opposition 1898.

Von *J. Stein*, S. J.

Der Planet wurde entdeckt von Charlois zu Nizza am 31. Dec. 1896. Damals war er von der Grösse 12.0. Die Beobachtungen sind sechs an der Zahl:

1897	M. Z. Nizza	$\alpha$ app.	$\log p.\Delta$	$\delta$ app.	$\log p.\Delta$	Vergl.-Stern
Jan. 2	$7^h 55^m 52^s$	$8^h 5^m 36^s 71$	9.661 <sub>n</sub>	$+23^\circ 22' 19''.0$	0.711	AG. Berlin B. 3293
12	9 18 32	7 56 24.68	9.535 <sub>n</sub>	$+24 25 23.2$	0.572	AG. Berlin B. 3251
26	8 35 4	7 43 9.87	9.490 <sub>n</sub>	$+25 42 52.7$	0.528	AG. Cambr. 4169
Febr. 24	10 1 57	7 26 35.71	9.061	$+27 11 59.0$	0.410	v Gemin. Paris
25	8 58 11	7 26 27.28	7.970 <sub>n</sub>	$+27 13 13.0$	0.395	
März 20	8 12 58	7 31 15.39	8.878	$+27 16 19.6$	0.396	AG. Cambr. 4094

Aus Jan. 2, 12, 26 berechnete Berberich die folgenden provisorischen Elemente:

Epoche 1897 Jan. 26.5 M. Z. Berlin

$$\left. \begin{aligned} M &= 40^\circ 3' 6''.5 \\ \omega &= 330 7 16.2 \\ \Omega &= 99 28 38.5 \\ i &= 8 10 17.2 \\ \varphi &= 6 21 8.4 \\ \mu &= 767'' 448 \\ \log a &= 0.443305 \end{aligned} \right\} 1897.0$$

Ich fand die folgenden Fehler (Beob. — Rechn.):

1897	$\Delta\alpha$	$\Delta\delta$
Jan. 2	$-2''.3$	$+0''.9$
12	$+1.7$	$+0.3$
26	$-1.4$	$+0.6$
Febr. 24	$-37.2$	$+12.3$
25	$-38.4$	$+13.0$
März 20	$-86.1$	$+21.5$

Mit Hülfe der Methode der kleinsten Quadrate versuchte ich obige Elemente zu verbessern. Dieses führte im Anfang zu keinem befriedigenden Erfolg, weil die Coefficienten von  $d\Phi$  und  $d\Psi$ ,

$$\Phi = \frac{\sin \varphi}{\sin i''} \sin \pi \quad \Psi = \frac{\sin \varphi}{\sin i''} \cos \pi,$$

in den Normalgleichungen sehr klein waren; es wurde sogar, in Folge einer ungenügenden Anzahl (5) von Decimalstellen in den Logarithmen, eine quadratische Summe negativ. Doch fand ich auf diesem Wege eine neue Gruppe von Elementen, wodurch der maximale Fehler in  $\alpha$  und  $\delta$  herabsank zu bezw.  $-32''.1$  und  $+6''.5$ . Aus diesen Elementen wurden

neue Normalgleichungen abgeleitet, mit Hülfe einer siebenstelligen Tafel. Die übrigen Correctionen wurden ausgedrückt als Functionen von  $d\Phi$  und  $d\Psi$ , und diese in die ursprünglichen zwölf Fehlergleichungen substituiert, woraus aufs neue zwei Normalgleichungen für  $d\Phi$  und  $d\Psi$  sich ergaben. Aus diesem Grunde verdienen die Correctionen der  $\varphi$  und  $\pi$  vielleicht weniger Zutrauen als die übrigen.

Schliesslich ergab sich:

Epoche 1897 Jan. 26.5 M. Z. Berlin

$$\left. \begin{aligned} M &= 40^\circ 0' 57''.60 \\ \omega &= 330 21 36.57 \\ \Omega &= 99 30 57.15 \\ i &= 8 11 56.89 \\ \varphi &= 6 11 49.62 \\ \mu &= 767'' 6789 \\ \log a &= 0.4432180 \end{aligned} \right\} 1897.0$$

mit den Unterschieden im Sinne Beob. — Rechn.:

1897	$\Delta\alpha$	$\Delta\delta$
Jan. 2	$-1''.0$	$-1''.6$
12	$+1.2$	$0.0$
26	$+0.6$	$+0.7$
Febr. 24	$+1.1$	$+1.9$
25	$+1.0$	$+2.1$
März 20	$+0.1$	$-2.8$

Mit diesen Elementen wurde die Ephemeride berechnet, mit Berücksichtigung der Störungen des Jupiter und des Saturn (Osculationsepoche 1897 Febr. 28.0); diejenigen der übrigen Planeten konnten ihrer Kleinheit wegen vernachlässigt werden. Die Störungen in den heliocentrischen Co-ordinaten betragen: