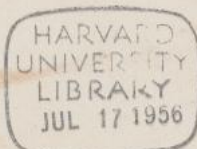


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Note Book.
No. 2.

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- Index.
- Pages
 20 Corrections of Period of π Persei. (Method of procedure).
- 32 { To correct the Period ^{Fund. Epoch} of a Variable Star. Typical Case =
 = R Z Cassiope.
- { A good example of correcting the period and epoch of a
 Variable Star by the graphical method wholly, is that of
 R H Tauri. (See Envelope with papers, and description on p. , this book).
- 36 { To correct the Period and ^{Fund.} Epoch of a Var. Star. Typical Case =
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Small Photo. Objective in brass tube.

This is the one I saw at the Laboratory and which was described to me by Mr. King.

Aperture about 2 inches. Ratio of aperture to focal length 1 to $4\frac{1}{2}$.

Price \$57.50. Kept by Robey French & Co.

Mr. King thinks it will take good images over a circle 3 inches in diameter, on the plate, which, he says, will correspond to an angle of about 20° in the sky. He also thinks it will probably take pretty good images over an angle of, perhaps, about 30° .

The above Photo. Instrument is made by Cooke & Sons, York, England, and is called Series II.

H. C. O. Observatory (Historic)

According to Professor Seale and Vol. 1 of Annals,
The Observatory House was erected in 1844 and occupied
in 1845.

The Lean Tower was begun in 1843, and the Great Telescope
was absolutely finished and in pos. accord. to report of Com. in Oct. 1847.
The Library end (East End) was finished in 1851.

The old Transit Circle was put up in 1840.

Prof. S. says that the house and the Lean Tower were
the first two buildings. The north end of the house
had a small extension for magnetic and meteor-
ological instruments, and the room in which Miss Willock
sits (East Room) was ^{connected} with house & tower & contained clock etc.
Prof. S. says that Professor H. C. Bond designed the
big chair in East Room, undoubtedly.

Prof. S. says my room (between East Room & Lean Tower) was
not built at first, probably, but was built for the Transit
Circle which was put up in 1840. Probably before that
there was a walk or covered way (to the main tower)
where my room is.

Bodies falling from an infinite distance.

We have $v^2 = 2gr^2 \left(\frac{1}{s} - \frac{1}{r} \right)$ (139) (Peck.)

Equation 139 gives the velocity generated whilst the body is falling from the height $\underline{h}$ to the height $\underline{s}$. If we make $\underline{h} = \infty$, and $\underline{s} = \underline{r}$, (139) becomes

$$v^2 = 2gr; \therefore v = \sqrt{2gr} \quad (140)$$

In this equation the resistance of the air is not considered.

If we make $g = 32.082 \text{ ft.}$ and $r = 20,923,596 \text{ ft.}$, their equatorial values, we find

$$v = 36,664 \text{ ft.} = 7 \text{ miles (nearly).}$$

In the above ^{solution} $\underline{r}$ is the radius of the Earth, supposed to be a sphere. g is the force of gravity at the surface of the Earth. $\underline{s}$ is any distance from the centre greater than $\underline{r}$.

The above formula (140) can be used for determining the velocity of fall for any planet by using the proper constants.

See Peck's "Analytical Mechanics" pp. 132, 133.

Bodies falling from an infinite distance con.

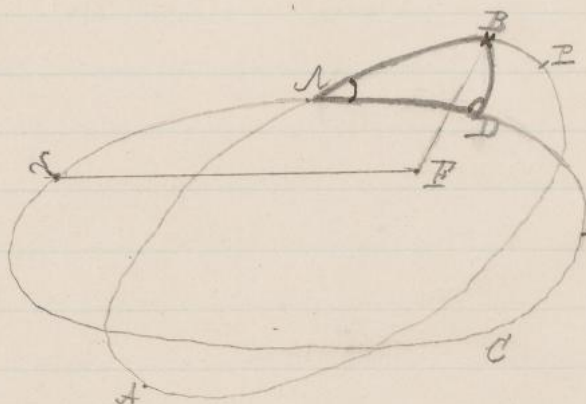
Using the formula on prec. page $= v = \sqrt{2gr}$ we can obtain the velocity with which a body falling from infinity would strike any planet.

The following values are copied from Moulton's "Introduction to Astronomy", p. 137.

Earth	=	6.95	miles	per	sec.
Moon	=	1.42	"	"	"
Sun	=	320.00	"	"	"
Mercury	=	2.45	"	"	"
Venus	=	6.37	"	"	"
Mars	=	3.13	"	"	"
Jupiter	=	37.16	"	"	"
Saturn	=	22.97	"	"	"
Uranus	=	13.13	"	"	"
Neptune	=	13.64	"	"	"

See also Moulton's "Celestial Mechanics" p. 43.

Concerning Orbits.



Let B be the place of a body in its orbit at a given time, to find its longitude reckoned on the Ecliptic throughout.

Let $r A C$ be the Ecliptic. — Let $A B P A$ be the orbit of the body. — Then the longitude of the body reckoned on the Ecliptic, is $r A$. For the balance of the longitude of B, reckoned on the Ecliptic, let fall a perpendicular on the Ecliptic from the point B, meeting the Ecliptic in the point D. Then, in the ^{spherical} triangle $A B D$, the angle at D is a right angle, and the angle at A is the inclination of the plane of the orbit to the plane of the Ecliptic, and the side $A B$ is given. — We want the side $A D$. Hence by Napier's rule

The triangle in question ($A B D$) will be a spherical triangle — all the sides being arcs of great circles.

~~Then, by Napier's rules, we have~~

Then we have $\sin BD = \sin AB \times \sin \angle$ at node.

$$\cos AD = \frac{\cos AB}{\cos BD}$$

AD is the projection of AB (in the orbit) on the Ecliptic.

In the above solution, Napier's rules (device) are not used but the ordinary rules of Spherical Trig.

Microscope.

The Observatory has just bought a Bausch & Lomb microscope.

The name of it is BH 4.

It ^(the outfit) includes 2 eye-pieces, and 2 objectives, - also a double nose piece and Iris Diaphragm.

The objectives are a $\frac{2}{3}$ and $\frac{1}{8}$.

The $\frac{2}{3}$ is also marked $\frac{1}{25}$ I. I. and also 16 mm.

(I think it was the $\frac{2}{3}$ that was so marked).

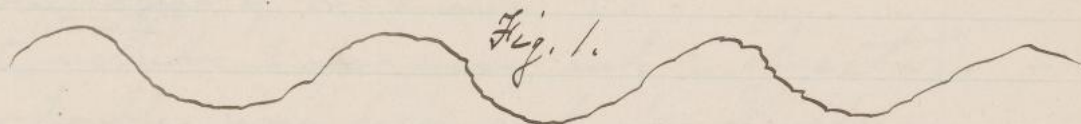
The cost to the Observatory of the complete outfit was \$31.50.

(See "Science" for July 1900, for advertisement of this instrument).

Mr. Gerrish thinks the 4 in BH 4, designates the amount and character of the auxiliary apparatus.

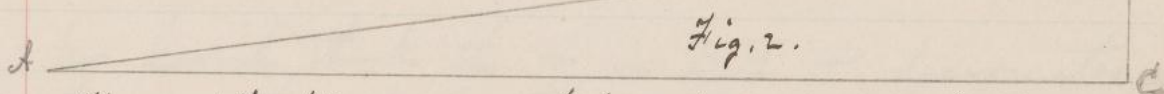
Formula for
To find the Period of a Variable Star.

- 1st Plot the obs. in Julian Days and Magn. ~~as~~ the curve being for instance as in Fig. 1.



- 2^d Then from Fig. 1. find an approximate period, ^{and epochs} and get out phases.

- 3^d Then, from ~~extreme observations~~ ^{runs} (the more widely separated the better), plot as in Fig. 2, the abscissas representing Julian Days and the ordinates, phases expressed in decimals of a day.



Then, with this new corrected period, repeat this process, if necessary, getting out phases from this ^{last} corrected period ^{as now}, as above, plotting, and correcting the period again.

- 4th Then, finally, correct the period by the U Cephei method - that is, by taking the diffs. of time between all the phases and the typical curve when the light is varying rapidly. (using, to enter the curve, the observed magnitudes, at these rapidly varying times.)

Formula for ^{com.}

To find Correction to Period, of a Variable Star.

Notes.

When one takes the differ. on sheet "Correction to Ephemeris" in the order (Col. 4 - Col. 5) we have the Correction to the Ephemeris. This is not the Correction to the Period. In order to determine the Correction to the Period, we must plot col. 6 (= Col. 4 - Col. 5) with Julian Days as abscissas and Col. 6 as ordinates and run a ~~line~~ line through this plot. Then, from this, we can determine the Correction to the Period per Julian Day, and then per Period.

We let the Correction to the Fundamental Epoch go till the last - that is, until the correction to the Period has been determined from the straight (or curved) line in the plot. (to correct the period)

Then, by taking the algebraic mean of the residuals ~~with~~ from the line in the plot which gives the correction to the Period and seeing how much this mean residual is above or below ~~the~~ (as the case may be) the zero of ordinates, we get the correction to the Fundamental Epoch.

(Note. One wants to assume some probable Fundamental Epoch at the first, ~~and~~ of course, and subsequently correct it).

Note. Indetermining the formula for a Var. Star, or correcting the formula previously used, the assumed, provisional, Fund. Epoch should not be corrected until after the period is corrected (as the Fund. Ep. for the time is a constant quantity.). After the period is corrected and new residuals got out, plot around the time of min. or max., as the case

To find Correction to Formula for a Variable Star.

Notes con. may be, on a large scale of abscissas and then by bisections, derive the correction to the Fundamental Epoch. - Or one can well plot the phases from old period and old Fundamental Epoch with Julian Days as abscissas and Phases as ordinates ^{when the star is varying rapidly} - that is, phases from the U Cephei method of Correction to Period - then from this, a new period can be derived, and then, by taking the sum of the plus and minus residuals (with reference to the zero datum line in the plot, the correction to the Fund. Epoch can be obtained, as was done in the case of u Herculis. (Sheet X).

The whole process can be repeated for another approximation.

To obtain magn. of an asteroid for a given date, having the magn. at mean opposition given, and also $\log r$ and $\log \Delta$ for the given date.

Let m_0 = magn. of Asteroid at mean Opp.

" g = $m_0 - 5 \log (a^2 - a)$

" M_0 = magn. for date (classical).

Then $M_0 = g + 5 (\log r + \log \Delta)$

The values of m and g are given in the Jahrbuchs. — g is so determined, as above, that all we have to do is to merely add $5 (\log r + \log \Delta)$ for the date, to g .

See Jahrbuch for 1910 [32], last towards of volume, under "Explanations".

See also Oppolzer, p. 92 — also Vol. 24, H. C. O. Annals, last part of vol.

Certain Fundamental Principles in connection with determining Formulae or Correction to Formulae for Variable Stars.

Suppose we have read up (for an Algol Var.) the abscissas of a point on the preceding as well as following side where the Variable is rapidly varying and then plotted the points for the prec. side and fol. side (with Julian Days as abscissas and the ^{vertical} readings on the prec. side and fol. side, separately, as ordinates) separately. Suppose, then, we have drawn a ^{straight line} ~~curve~~ through these ^{plotted} values in each case separately and balancing them. Now suppose these balancing lines for the two sides are not parallel and we wish, nevertheless, to bring the readings together into one plot. For illustrative sheet A, we would take the mean of the Julian Days of the runs ^{on prec. side and fol. side} finding this to be at E' , the breadth of the curve ^{at the point ready} would be the dotted line $E'F'$.

For illustrative sheet B, we would take the mean of the Julian Days of the runs on the Preceding and Following sides, - there, the former ^{mean} falling at E and the latter mean at F , the breadth of the curve ^{at the point ready} would be the dotted line EF .

(Jan. 25, 1909)

Z Persei. Derivation of corrected period:

The pl. method was used in correcting Period of Z Persei.

- 1st. Read up (for 4 runs on fol. side of curve) phases at magn. +2.50 (rapidly varying point of curve).
 - 2d. Plotted these 4 points on sheet a with Julian Days as abscissas and these phases as ordinates. Then ran a line through them and determined correction per Julian Day, and then per Period. This gave for correction per Period $-.00012$, making new previous, corrected Period = 3.05644 (the original period being 3.056623).
 - 3d. Derived phases in ledger from this new period, still using the old Fundamental Epoch.
- In this procedure, only phases for rapidly varying parts of curve were got out first, ~~first~~ and then plotted. This plot showed the the Period was well corrected so that all the phases were then obtained on this basis.

There was not enough material to bring in any rapidly varying observations from preceding side of curve (and it does not seem to be needed) nor to correct the Fundamental Epoch, so that the ^{corrected} formula now is

$$2416009.6934 + 3.05644 E^v$$

Williams' Formula, used previously, was

$$2416009.6934 + 3.056623 E^v$$

(See A. U. 160, 63)

R Z Cassiop.

Correction of Fundamental Epoch + Period.

Typical method.

The Formula originally used for phases, was Müller's, given in A. N. 171. 359.

This Formula is $2417355.427 + 1.49508$.

It was this Formula that was corrected by the following, typical method. —

Having certain preliminary methods and trials, the vital part of the process was as follows.

1. All the observations at time of variation were plotted on sheet a.
2. The values of the abscissas at diff. magn. -2.0 were ^{then} read up for both prec. and fol. side, and $.020$ (assumed as $\frac{1}{2}$ the breadth of curve at diff. magn. -2.0) added to prec. side and subtracted fol. side readings at -2.0 . This reduced the points on both sides to minimum. These quantities are given in the second col. (for epochs in first col.) on sheet a.
3. These quantities were then plotted on the upper part of sheet b. An arbitrary line AB, showed that the crosses and dots seemed to show a slight systematic difference between themselves. — in other words, that $.020$ (used) was not the true $\frac{1}{2}$ breadth of the curve at diff. magn. -2.0 . To determine the correction to $.020$, the crosses and dots were read up with reference to the line AB. — those above the line

R Z Cassio. cor.

being called plus and those below the line, minus. These quantities are found in the second col. of sheet B for epochs in first col. of same sheet. By this method it was found that the curve should have ~~at~~ a breadth of .006 more (or the $\frac{1}{2}$ curve, of .003 more) at diff. mag. -2.0. This correction is found in the 3d. col. on sheet A, and its applied value in 4th col. of same sheet.

4. Then, to determine the Correction to the Period, a Least Square Solution was made on Sheet C. - the first col. representing epochs when the light was rapidly varying and the fourth col. representing the corrected values from col. 4 of Sheet A. - the corresponding epochs being taken from col. 1. of same sheet.

The correction to the period, by this solution, was $+0.00025$ ^{period}. This, added to the period 1.1950 made the corrected 1.19525 . The value 1.19526 was adopted.

5. To determine the correction to the Fundamental Epoch, we have $y = ax + b$. Or, substituting the necessary values from Sheet C, we have

$$0.1301 = 0.00026 (527.3) + b$$

$$\therefore b = +0.1301 - .1371 = -.007 = \text{Correction to Fund. Ep. (See sheet D).}$$

$$\therefore \text{Corrected Formula} = 2417355.420 + 1.19526 \delta.$$

R T Persei.

Correction of Fundamental Epoch and Period.

Typical Method.

The formula to be corrected was (See A. N. 166, 155)
 $= 1904. \text{ Sept. } 17^{\text{d}} 5^{\text{h}} 45^{\text{m}} \text{ G. M. T.} + 20^{\text{h}} 23^{\text{m}} 11^{\text{s}} \text{ E.} =$
 $= 2416741.23952 + 0.249433 \text{ E.}$

A plot of the observations during the time when the variable was varying was made on Sheet a.

Then the different runs were read up at Diff. Magn. +1.74 and tabulated on Sheet b for preceding and following sides.

Then a plot was made on Sheet c (for prec. and fol. sides) with Jul. Days as abscissas and the diff. (in dec. of a day) between the zero at the bottom of Sheet a and the points of runs at Diff. Magn. +1.74, as ordinates.

Then a balancing line was drawn through the upper points (crosses, fol. side) and also through the lower points (dots, prec. side).

Then the diff. in height of these two balancing lines, on Sheet c, were read up for Jul. Days 6600 and 2600 and tabulated on Sheet d. The mean of these values was taken and gave for the breadth of the curve 0.050 at diff. magn. +1.74.

Then on Sheet e, this breadth (0.050) was added to the Prec. side values in order to reduce them to the fol side and plot them with the fol. side

R T Persei. con.

values (already plotted) along upper balancing line (previously drawn to balance fol. side crosses only).

This was done in order to see if the assumed breadth of curve (0.050) was correct or whether the upper balancing line for the crosses, needed to be changed in order to balance the dots also.

Correction to Period + Fund. Epoch of Variable Stars.

Hints and Suggestions.

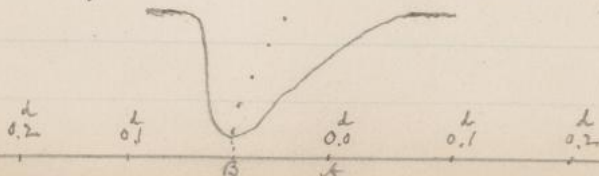
A good way to get out final correction to the Period from a long or progressive series of observations, is the so called U Cephei method - that is, the method I use continuously on U Cephei.

When one uses the U Cephei method of Correcting the Period of an Algol, the Correction to the Ephemeris, viz: (Phase - Curve) ^{for both, period & fol. givings} reduces the Correction to the minimum Point at once without applying any correction for half breadth of curve.

Suppose, however, as in the case of the Light Curve used for u Herculis (in the U Cephei method) the middle point of the plotted ^{+ drawn} typical Light Curve does not correspond to the zero on the sheet (as the period + Fund. Ep. from which it was plotted was not quite right) and we use this curve as it stands, ^{for Curve column,} then we must apply a correction sometime, for this lack of coincidence.

The correction will be the diff. between the minimum point of the typical Light Curve and the zero of the sheet on which it is plotted, applied with the proper sign.

This is also true if the two sides of the Light are not symmetrical and ~~do~~ so do not have quite the same velocity or contour. For, example, the correction in all cases, is AB, with the proper sign, as in the illustrative case below.



R Z Draconis, and others of the β Lyrae type.

Took $\frac{1}{4}$ part of period (15°) for reading up most of final, smoothed curve, - but as this would not do for the very first and last parts of curve where the curve was steep and the variable varied fast, plotted this first and last parts on a larger scale of abscissas (sheet 2) for every 3° ($\frac{1}{20}$ part of period) and extended the curve a little beyond the 3° parts, to make the first 3° part smooth ^{with the rest}. Then read up on sheet 2 the smooth curve drawn (3° curve) for every .01 day ~~and~~ up to .05 day incl. and plotted these points in red, on the general, complete curve - did the same at end of complete curve, and then drew a smooth curve through the whole of the complete curve.

