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On the Spectrographic Investigation of the Rotation Period of the Planet Venus.

By *Percival Lowell*.

In order to test spectrographically the rotation period of Venus, a spectrograph was ordered by this observatory of Brashear in December, 1900. For the purpose in hand it was necessary that the instrument should be powerful, as the quantity to be measured was very small. The instrument was therefore made to be as efficient as possible. It was fitted with a diffraction grating and with a train of three prisms. The prisms justified the constructor's high opinion of them as is shown by the following tests.

Mr. Slipher has determined the efficiency of the prisms first for the question of dispersion and second for that of definition both of which are important in the measurement of the spectral lines. For a camera tube of 386 mm in length, the one employed in these researches, he found the dispersion for the *H γ* line to be 12.98 tenth metres to the millimetre. This makes the dispersion of the train of prisms as compared with that of the Mills spectrograph and the Potsdam III spectrograph as follows:

Spectrographs	Dispersion for one tenth metre
Mills	40"5
Potsdam III	39.7
Lowell Observatory	41.2

With regard to the definition he made tests on the close lines which could be separated on the photographs made of the solar spectrum with the results here given:

Spectr. lines	$\Delta\lambda$	Int.	Separation
4058.915:	.166	3	Widely separated
4059.081:		3	
4076.644:	.148	2	Separated
4076.792:		4	
4096.129:	.133	3	Separated
4096.262:	.105	2	
4096.367:		1	Not separated
4106.420:		2	
4106.583:	.163	2	Widely separated
4111.021:		1	
4111.154:	.133	1	Just separated
4122.673:		3	
4122.819:	.146	1	Separated
4134.494:		3	
4134.589:	.095	3	Just separated
4142.330:		2	
4142.465:	.135	2	Just separated

Spectr. lines	$\Delta\lambda$	Int.	Separation
4142.629:		2	Indication of separation
4142.744:	.115	2	
4156.471:	.141	3	Separated
4156.612:		1	
4156.831:	.139	1	Separated
4156.970:		3	
4161.239:	.130	2	Well separated
4161.369:		2	
4171.068:	.145	4	Separated
4171.213:		4	
4229.926:	.149	3	Separated
4230.075:		1	
4235.298:	.152	2	Clearly separated
4235.450:		3	
4239.890:	.124	3	Clearly separated
4240.014:		3	
4395.201:	.212	3	Well separated
4395.413:		2	

For the Mills spectrograph Prof. Campbell states: »in the solar spectrum, the limit of resolution with proper exposures on Eastman's lantern slide plates is about 0.15 t.m.; lines for which $\Delta\lambda = 0.20$ t.m. are rather widely separated« *).

How much the excellent definition of these prisms is their own and how much the result of steady air is an interesting question. Unsteady air means that waves of condensation and rarefaction are passing rapidly between object-glass and object. These produce the effect of prisms rapidly interposed and as rapidly withdrawn beyond the end of the telescope. Thus spectral lines of different wave-lengths would be impressed with unequal duration and therefore give unequal intensities and unequal widths on the plate; secondly, different parts of the object would successively fall upon the slit and give wave-lengths affected by the motion of those parts; this is very important in a research like the present one. Both circumstances would give rise to more or less blurring. Whether the first be for much or little in the result, certain it is that the second must affect the result to a great extent and that consequently the situation of the observatory was a favorable factor in the investigation. Its site being 7250 ft. or 2210 metres above the level of the sea the barometer stands at 23 inches instead of 30 and much of that objectionable bar to astronomic perfection, the atmosphere, is got rid of. The latitude $35^{\circ} 11'$ was also bene-

*) *Astrophysical Journal*, Oct., 1898.

ficial helping to raise the altitude of the planet and thus conduce to better definition. But the chief value of the site lies in the relatively steady character of the air for which quality it was originally selected. Though not so important spectroscopically as visually it is nevertheless a factor to be taken into account.

As to the advantages of the time chosen for the research in its bearing on the result they are set forth by Mr. Slipher in his article as is also the manner an ingenious one in which he reduced systematic error to as nearly nul as possible.

Mr. Slipher was left entirely unbiassed in his investigation. In order furthermore to render himself unprejudiced in his measurements, in every case where he could have occasion to recognize or to think he recognized a plate, a paper covering up the plate number and bearing a fictitious number written without his knowledge by an assistant was

Lowell Observatory, 1903 March 28.

put over the plate mark and was not removed until, not only the plate was measured, but practically the whole investigation closed.

His result follow. It is noteworthy that the value got with the slit parallel to the terminator is very nearly the value of the probable error in the investigation for the motion with the slit perpendicular to the terminator. This is of course what it should be as the probable error means that where no force is at work the result got would probably differ from zero by just this amount.

From the efficiency of the instrument and the unbiassed manner in which the measurements were made we may, I think, conclude from the size of the probable error that the evidence of the spectroscope is against rotation of short duration and that so far as its measure of precision permits the investigation confirms a rotation period of 225 days.

Percival Lowell.

A Spectrographic Investigation of the Rotation Velocity of Venus.

By V. M. Slipher.

If v is the velocity of a point on the equator of Venus, due to axial rotation; then the relation between the rotation and spectrographic velocity is given by the equation,

$$v_s = 2v(1 + \cos i),$$

where i is the angle Earth-Venus-Sun, and v_s is the spectrographic velocity corresponding to the opposite displacement of the planetary lines at the edges of the spectrum the slit of the spectrograph being set on the planet's equator. For Venus at superior conjunction $i = 0^\circ$ and $v_s = 4v$, at elongation $i = 90^\circ$, $v_s = 2v$, and at inferior conjunction $i = 180^\circ$, $v_s = 0$. Thus to gain most from the condition that Venus shines by reflected sunlight the observations must be made when i is small. The present passage of Venus through superior conjunction gave an opportunity to investigate the rotation velocity under favorable conditions. An investigation of this kind was made by A. Belopolsky¹⁾, at Pulkowa, in 1900, but when the planet was near elongation. Although I began observations the first of last November, the nearness of the planet to the Sun and unfavorable weather allowed me to secure only a few satisfactory plates before the middle of February. Plates secured since that time were made in a manner which so facilitated the measurements, that I have preferred not to include measures from the early plates, although those measured gave results in entire accord with those from the later ones given below.

In the above equation the factor

$$2(1 + \cos i) = K$$

is known when i is given. The values of i , K ²⁾ and the semidiameter of Venus for the dates of the observations are given in the following table:

1903	i	K	Semidiam.
Febr. 23	29°6	3.8	5".47
Mar. 2	31.3	3.7	5.56
7	33.1	3.7	5.63
12	35.0	3.6	5.71
19	37.6	3.6	5.83

This apparent diameter gave the spectrum a breadth on the plates of a little more than 0.4 mm.

In this work the new three-prism spectrograph was employed, attached to the 24-inch refractor. A comparison of the optical power of this and other large spectrographs is given, by Director Lowell in his paper. For the region of the spectrum measured the linear dispersion is about 11.5 tenth metres to the millimeter. It is arranged with two devices for guiding, the one by light reflected from the first prism, the other, by light from the slit-plate. I have found guiding by the latter method more accurate, especially for planetary work, since one can see what part of the disk is on the slit. The attachment of the spectrograph to the adapter is such as to readily permit rotation through any desired angle about the optical axis of the telescope. This made easy the obtaining of plates with the slit in different positions.

Since measures from my first plates gave no certain evidence of rotation I was convinced that the displacement must be very small even with the considerable dispersion employed. These early results, undecisive as they were, lead me to take every possible precaution against instrumental errors and any personal systematic errors in the measurements. To effect the elimination of such errors as far as possible, I made the plates with the spectrograph in the following positions:

¹⁾ See *Astronomische Nachrichten*, No. 3641.

²⁾ This is the same as Belopolsky's k .