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ART. VII.—*Note on the supposed Discovery of the Principle of the Differential Calculus by an Indian Astronomer. By* W. SPOTTISWOODE, Esq. *Communicated by the Director.*

IN the number of the Journal of the Asiatic Society of Bengal last received, No. III., of 1858, is a short article by Bapu Deva Shastri, Professor of Mathematics and Astronomy at the Government College of Benares, in which he has undertaken to show, that Bháskaráchárya, an astronomer who flourished at Ujjayin in the twelfth century, was fully acquainted with the principle of the Differential Calculus, one of the most important discoveries of the last century in Europe.

As this would have been a very remarkable circumstance in the history of astronomical science, it was obviously a matter of more than ordinary interest to have the accuracy of Professor Bapu Deva's statement carefully tested, and I therefore applied to our colleague, Mr. William Spottiswoode, who is well known as a mathematician, for his opinion; the answer with which he has favoured me will, I doubt not, be thought by the Society worthy of being communicated to the public through our Journal, especially as, whilst it shows that Bapu Deva's statement is not correct to its whole extent, yet it does full justice to Bháskaráchárya's penetration and science, and acknowledges that his calculations bear a very remarkable analogy to the corresponding processes in modern mathematical astronomy.

12, James Street, Buckingham Gate,
London, May 5, 1859.

MY DEAR MR. WILSON,

I have read Bapu Deva Shastri's letter on Bháskaráchárya's mode of determining the instantaneous motion of a planet, with great interest, and think that we are much indebted to him for calling our attention to so important an element in the old Indian methods of calculation. It still, however, seems to me, that he has overstated the case, in saying that "Bháskaráchárya was fully acquainted with the principle of the Differential Calculus." He has undoubtedly conceived the idea of comparing the successive positions of a planet in its path, and of regarding its motion as constant during the interval, and he may be said to have had some rudimentary notion of representing the arc of a curve by means of auxiliary straight lines. But on the other hand, in the method here given, he makes no allusion to one of the most essential features of the Differential Calculus, viz., the infinitesimal magnitude of the intervals of time and space therein employed. Nor indeed is anything specifically said about the fact that the method is an approximative one.

Nevertheless, with these reservations, it must be admitted, that the penetration shown by Bhaskara, in his analysis, is in the highest degree remarkable; that the formula which he establishes (equation 3, p. 216), and his method of establishing it, bear more than a mere resemblance—they bear a strong analogy—to the corresponding process in modern mathematical astronomy; and that the majority of scientific persons will learn with surprise the existence of such a method in the writings of so distant a period and so remote a region.

With many thanks for communicating the paper to me,

I remain, very sincerely yours,

H. H. Wilson, Esq. W. Spottiswoode.

P.S. I may perhaps add, that if—

x, x' be the mean longitudes,

y, y' be the mean anomalies,

u, u' be the true anomalies

of a planet on two successive days; and a the excentricity, or sine of the greatest equation of the orbit; then $(u'-u)$, or the true motion of the planet,

$$= x' - x \; a \pm (\text{sin. } y' - \text{sin. } y).$$

And Bhaskara's method consists in showing, that the "instantaneous" value of sin. $y' -$ sin. y (or the value which it would have if the velocity of the planet had remained uniform during the day) is $(y' \dot{-} y)$ cos. y. His formula therefore becomes—

$$u' - u = x' - x \pm (y' - y) \, a \text{ cos. } y.$$

And the corresponding formula in modern analysis is—

$$\begin{aligned} du &= d\,(x \pm a \text{ sin. } y) \\ &= dx \pm a \text{ cos. } y \, dy. \end{aligned}$$

W. S.

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