

photographs reproduced in the accompanying plate, which were made with a three-prism spectrograph attached to the 40-inch telescope, are fairly well adapted for the purposes of this comparison. It will be seen that in the region extending from b_4 to about $\lambda 5300$, the spectra of μ Geminorum (type III) and 132 *Schjellerup* (type IV) are almost identical, while there are many common lines in the neighboring less refrangible part (the slight difference in scale of the two photographs is not sufficient to render the comparison difficult). Further toward the red the spectra become very unlike, though even here there are certain important points of resemblance which must be carefully investigated. The agreement of the spectra of the two stars is quite as striking in a limited region lying between $H\beta$ and $H\gamma$. In fact, it may be said that within certain limits in both the green and blue regions the spectrum of μ Geminorum more closely resembles that of 132 *Schjellerup* than do the spectra of certain stars of the *fourth* type. It is interesting also to notice that between b_4 and $\lambda 5300$ the spectrum of μ Geminorum agrees more perfectly with the spectrum of 132 *Schjellerup* than it does with the solar spectrum (type II).

These photographs serve to confirm the common belief in the essential similarity of the two types of red stars, and may perhaps afford material for a study of their development.

GEORGE E. HALE.

April 12, 1899.

A NEW SATELLITE OF SATURN.¹

NEARLY all of the astronomical discoveries made by the aid of photography have related to the fixed stars. In the study of the members of the solar system, the results obtained by the eye are generally better than those derived from a photograph. For many years it has been supposed that photography might be used for the discovery of new satellites, and in April 1888, a careful study of the vicinity of the outer planets was made by Professor William H. Pickering. Photographs were taken with the 13-inch Boyden telescope, with exposures of about one hour, and images were obtained of all the satellites of Saturn then known, except Mimas, whose light is obscured by that of its primary. It was then shown that Saturn probably had no satellite, as yet undiscovered, revolving in an orbit outside of that of Enceladus,

¹ *Harvard College Observatory Circular* No. 43.

unless it was more than a magnitude fainter than Hyperion. (Forty-third Report, p. 8.)

In planning the Bruce photographic telescope, a search for distant and faint satellites was regarded as an important part of its work, and accordingly, plates for this purpose were taken at Arequipa, by Dr. Stewart. A careful examination of these plates has been made by Professor William H. Pickering, and by superposing two of them, A 3228 and A 3233, taken August 16 and 18, 1898, with exposures of 120^m , a faint object was found which appeared in different positions on the two plates. The same object is shown on two other plates, A 3227 and A 3230, taken August 16 and 17, 1898, with exposures of 60^m and 122^m , respectively. The position is nearly the same on the two plates taken August 16, but on August 17 it followed this position $33''$, and was south $19''$, while on August 18 it followed $72''$, south $43''$. Its motion was direct, and less than that of Saturn, though nearly in the same direction. It cannot, therefore, be an asteroid, but must be either a satellite of Saturn or a more distant outside planet. The proximity of Saturn renders the first supposition much more probable. On August 17, the position angle from Saturn was 106° , and the distance $1480''$. Assuming that it was at elongation, and that its orbit is circular, its period would be 400 days, or five times that of Iapetus. It was at first identified with a very faint object found on plates taken in 1897, and the period of seventeen months was derived from them. This supposition has not been confirmed.

Measurements of the positions of the images give additional material for determining the form of the orbit. The method of measurement is that described in the *Annals*, 26, p. 236. The uncorrected positions of the four images referred to the first plate of August 16 as an origin are for x , $0.0''$, $+1.2''$, $+33.6''$, and $+71.8''$; for y , $0.0''$, $-1.7''$, $-19.8''$, and $-42.1''$; the corresponding Greenwich mean times are $12^h 16^m$, $14^h 18^m$, $12^h 56^m$, and $13^h 12^m$. Correcting for the motion of Saturn, the relative motion with references to that body is in x , $0.0''$, $-2.4''$, $-10.7''$, and $-22.0''$; in y , $0.0''$, $+0.1''$, $+2.4''$, and $+2.9''$. It appears from this that the apparent motion is about $10.4''$ a day, at a distance of $1480''$. A computation shows that if the orbit is circular, the period must be either 4200 or 490 days, according as the satellite is near conjunction or elongation. These values may be greatly altered if the orbit is elliptical. Since the interval of time between the first and last photographs on which the satellite appears is only two days,

it is impossible to predict its position with accuracy. It is probable that its position angle from Saturn now lies between 280° and 290° , and its distance between $20'$ and $30'$. These uncertainties will probably be greatly diminished from measures of plates of Saturn taken in Arequipa on September 15, 16, and 17, 1898, which for some unexplained reason have not yet been received in Cambridge.

The direction of the motion, which is nearly towards Saturn, shows that the apparent orbit is a very elongated ellipse, and that it lies nearly in the plane of the ecliptic. Professor Asaph Hall has pointed out that this is to be expected in a body so distant from Saturn. The attraction of the latter only slightly exceeds that of the Sun. Hyperion appears as a conspicuous object on all four of the plates, and the new satellite appears about a magnitude and a half fainter on each. The approximate magnitude is therefore about 15.5. As seen from Saturn, it would appear as a faint star of about the sixth magnitude. Assuming that its reflecting power is the same as that of Titan, its diameter would be about two hundred miles. It will, therefore, be noticed that while it is probably the faintest body yet found in the solar system, it is also the largest discovered since the inner satellites of Uranus in 1851. The last discovery of a satellite of Saturn was made in September 1848, by Professor William C. Bond, then director of this Observatory, and his son, Professor George P. Bond. The satellite Hyperion was seen by the son on September 16 and 18, but its true character was first recognized on September 19, when its position was measured by both father and son (see *Annals*, 2, p. 12). Soon after, it was discovered independently by Lassell at Liverpool.

Professor William H. Pickering, as the discoverer, suggests that the name Phoebe, a sister of Saturn, be given to the new satellite. Three of the satellites, Tethys, Dione, and Rhea have already been named for Saturn's sisters, and two, Hyperion and Iapetus, for his brothers.

EDWARD C. PICKERING.

April 10, 1899.

CHANGE OF ADDRESS.

I regret to state that Professor F. L. O. Wadsworth, who has been connected with the Yerkes Observatory from the beginning of its work, has resigned his position on the staff. His present address is 283 Lincoln Avenue, Bellevue, Pa., where all letters intended for him should be addressed:

G. E. H.