Minor Contributions and Notes

OBSERVATIONS OF THE SPECTROSCOPIC BINARY *CAPELLA*.[1]

The first magnitude star *Capella* was discovered to be a spectroscopic double star early in August, 1899, from an examination of the plates of its spectrum secured with the Mills spectrograph in 1896. Announcement of the fact was made to the Astronomical and Astrophysical Society of America at the meeting of September 7, 1899, and in the Astrophysical Journal for October, 1899.

Independent discovery of its binary character was made by Mr. H. F. Newall, of Cambridge, England, in November, 1899, and announced in the *Monthly Notices of the Royal Astronomical Society* for November.

The spectra of the two components are distinguishable on most of the plates—the exceptions being those taken when the radial velocities of the two were nearly equal, producing a superposition of the two sets of lines. The spectrum of the principal star is of the solar type, whereas that of the secondary is intermediate between the solar and Sirian types.

The velocities of the principal component, as observed with the Mills spectrograph, are given in the following table:

No.	Date. Greenwich M. T.	Velocity. Kilometers.	No.	Date. Greenwich M. T.	Velocity. Kilometers.
1	1896 Sept. 1.036	+36.4 C	17	1899 Nov. 6.026	+54.8 C
2	17.005	53.8 C	18	27.952	43.2 W
3	Oct. 4.003	50.3 C	19	27.966	44.0 W
4	6.029	46.9 C	20	Dec. 3.730	35.2 C
5	Nov. 12.865	4.2 C	21	18.648	12.6 W
6	1899 Aug. 12.999	48.3 C	22	24.882	7.7 W
7	27.052	26.1 C	23	1900 Jan. 10.649	7.7 C
8	Sept. 12.950	5.7 W	24	21.740	21.7 W
9	20.006	5.1 W	25	Feb. 11.724	50.0 W
10	20.919	3.5 W	26	26.726	55.2 W
11	20.933	5.4 W	27	26.740	54.8 C
12	25.909	6.6 C	28	Aug. 2.012	3.6 C
13	Oct. 3.988	14.8 C	29	Sept. 19.944	55.5 C
14	16.912	32.9 C	30	24.950	53.9 C
15	16.929	32.0 C	31	27.005	53.7 C
16	31.892	52.0 C			

[1] *Lick Observatory, University of California, Bulletin* No. 6.

[Measures of the plates by Campbell and Wright are indicated by C and W respectively.]

The presence of the second component's spectrum interferes considerably with the measures of that of the first component, and the probable error of a single observation, ±0.50 kilometer, deduced by Dr. Reese, is as small as could be expected. Measures of the speed of the second component are somewhat uncertain, but an estimated range of from −3 to +63 kilometers will not be far from the truth. The velocity of the principal component in the line of sight ranges from +4.2 to +55.7 kilometers. The masses of the two components are therefore as 1.26 to 1.

The solar-type component is estimated to be half a magnitude brighter, photographically, than the bluer component. In the visual portion of the spectrum the solar component is probably at least a whole magnitude the brighter of the two.

Inasmuch as the spectroscope takes account of the component of speed in the line of sight, and is powerless to measure the component at right angles to the line of sight, the spectroscopic orbit is determinate in form but indeterminate in size. The inclination of the orbit-plane remains unknown. The minimum orbit capable of satisfying the observed velocities corresponds to the case of the orbit-plane passing through the observer. In this case the maximum distance between the two components would be about 85,000,000 kilometers; and, if Elkin's value of the parallax of *Capella*, 0".08, is correct, the angular separation of the components, as viewed from the solar system, would approximate 0".045 when passing through the nodes. Such an orbit would give rise to eclipses every fifty-two days. No variations in the brightness of *Capella* having been observed, it is safe to assume that the orbit-plane makes an appreciable angle with the line of sight.

In the case of a great number of orbit-planes distributed fortuitously, the most probable value of the angle between the normal to the orbit-plane and the line of sight would be 60°. The corresponding angular separation of the components at the nodal points would be about 0".052. In case this angle should be 30°, the corresponding separation would be 0".09.

The question as to whether *Capella* could be observed as an ordinary double star early arose. It was most carefully examined with the 36-inch refractor on several occasions in 1900 and 1901 by Messrs. Hussey and Aitken, and on one occasion by Mr. Perrine; but neither

duplicity nor elongation could be detected. Their observations were made under the most favorable conditions, and we may conclude that the angular separation of the components is less than 0".06.

A discussion of the probable masses of the components with reference to the mass of our Sun seems to be futile, on account of the impossibility of harmonizing the best available data for the parallax and brightness of *Capella*, the brightness of our Sun, and the angular separation of the components.

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A DETERMINATION OF THE ORBIT OF *CAPELLA*.

The announcement that *Capella* is a spectroscopic binary was made by Professor Campbell in the ASTROPHYSICAL JOURNAL for October, 1899, and afterwards by Mr. H. F. Newall in the *Monthly Notices of the Royal Astronomical Society* for November, 1899. It will be recalled that Vogel and Scheiner had photographed the spectrum from October 6, 1888, to September 15, 1889; but failed to detect its binary character, their spectroscope being apparently incapable of resolving the composite spectrum. Consequently their measurements give the mean displacements of two sets of lines, and their reductions an approximation to the velocity of the center of mass of the system.

The following computation is based on thirty-one observations of the velocity in the line of sight of the solar-type component, made with the Mills spectrograph at intervals between September 1, 1896, and September 27, 1900. The plates were exposed and the measurements and reductions carried out by Director Campbell and Mr. W. H. Wright. The method of computing the orbit is exactly that given by Lehmann-Filhés (*Astronomische Nachrichten*, No. 3242), except that in the equations of condition the correction to the velocity of the center of mass of the system is introduced as a sixth unknown, with coefficient unity. The period 104.1 days was assumed as best agreeing with the observations, and the observed velocities were plotted as functions of the time-interval after the next preceding minimum, assuming September 18.9, 1899, as a time of minimum. A smooth curve was drawn through the points so obtained, and by means of a planimeter the line representing the velocity of the center of mass of the system was drawn so as to enclose equal areas with the portions of the curve above it and below it. The other requisite quantities were then obtained in the way shown in the article already cited. The following is the list of provisional elements thus found: