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DEPARTMENT OF THE INTERIOR
CANADA

HON. CHARLES STEWART, *Minister*

W. W. CORY, C.M.G., *Deputy Minister*

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OTTAWA

R. MELDRUM STEWART, M.A., *Director*

Vol. IX

Astrophysics

No. 2

THE SPECTROSCOPIC SYSTEM SIGMA SCORPII
THIRD PAPER

BY

F. HENROTEAU, D.Sc.

OTTAWA
F. A. ACLAND
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THE SPECTROSCOPIC SYSTEM SIGMA SCORPII

THIRD PAPER

BY F. HENROTEAU, D.SC.

The second paper on σ Scorpii concerned the observations of 1922. A number of additional observations were obtained in 1923 and 1924. These indicate that σ Scorpii is almost without doubt a real triple system, revolving in a fairly short-period orbit of 33^d.0, but the centre of mass of this orbit most probably revolves around a third body in a period of several years. If we except cases like α Ursae Minoris¹, where the shorter period of radial velocity oscillation may be ascribed to some kind of pulsation (Cepheid), and like κ Pegasi², where the longer period of revolution was discovered as a visual binary, σ Scorpii would be the rare case of a triple system discovered entirely from measures of spectrograms. To this are added the interesting facts that it may be considered as a Cepheid, that it has stationary *H* and *K* lines of calcium, and that elements of its longer period orbit can be obtained from the equation of light indicated by advance or retardation of the observed maxima of the six-hour period of Cepheid variation: σ Scorpii is thus a system at present unique of its kind.

All the spectrograms of 1923 and 1924 have been measured on the spectro-comparator. This method of measuring them was found more reliable, quicker and giving results of greater homogeneity. An excellent spectrogram of β Canis Majoris was used as a standard, the same that was used for all the measures of β Cephei, δ Ceti and other stars of early class B.

A complete re-examination of former measures was made. The conclusion was arrived at that the 33-day period curves of 1920 and 1921 were not based on enough observations to be determined accurately; the measures of 1921 are good although perhaps not as good as those of 1922-23-24; the plates of 1920 were all remeasured on the spectro-comparator; the results obtained are probably more reliable and indicate a curve of larger amplitude than that found previously. Although there is not such a large variation of amplitude of the long-period curve as apparently obtained in the first paper, a variation of shape and amplitude certainly exists, which could be ascribed to the perturbing effect of a third body. When observations will have been secured for a few more years, they will offer a most interesting problem of sidereal mechanics.

Equal shares in the observations, measures and reductions of 1923-24 have been taken by Messrs. J. F. Frédette, R. Callander and the writer.

A list of the radial velocities of 1923-24 is given here, followed by a new list of the velocities of 1920 as obtained by remeasuring the spectrograms on the spectro-comparator.

¹ Pub. Dom. Obs. Vol. 9, No. 1.

² L.O.B. Vol. 9, p. 120.

RADIAL VELOCITIES OF σ SCORPII

| Date | Julian Day | Velocity km. | Remarks |
|-------------------|-------------|-----------------|---------------------|
| 1923 April 9..... | 2423519.752 | -48.1 | |
| | .775 | -44.5 | |
| | .798 | -78.4 | Poor plate. |
| | .819 | -47.0 | |
| | .836 | -34.8 | Mean of 2 measures. |
| | .874 | - 2.5 | |
| | .900 | + 9.1 | |
| April 11..... | 521.733 | -39.0 | |
| | .762 | -55.1 | |
| | .789 | -25.6 | |
| | .812 | -31.4 | |
| | .833 | -14.8 | |
| | .851 | -13.4 | |
| | .872 | +25.6 | Poor plate. |
| | .898 | +15.8 | |
| April 13..... | 523.736 | -54.3 | |
| | .764 | -52.2 | |
| | .789 | -29.7 | |
| | .812 | -20.1 | |
| | .837 | - 2.8 | |
| April 14..... | 524.758 | -59.0 | Poor plate. |
| | .783 | -30.7 | |
| | .808 | - 6.3 | |
| April 17..... | 527.710 | -42.0 | |
| | .735 | -31.2 | |
| | .756 | -15.1 | |
| | .776 | - 4.4 | Poor plate. |
| | .796 | +20.8 | |
| | .816 | +16.0 | |
| April 18..... | 528.733 | -24.0 | |
| | .757 | - 2.9 | |
| | .779 | + 4.4 | |
| | .806 | +22.0 | |
| April 23..... | 533.710 | +35.6 | Poor plate. |
| | .737 | +79.4 | Good plate. |
| | .769 | +25.5 | |
| | .799 | +15.1 | |
| April 24..... | 534.710 | +63.3 | Poor plate. |
| | .759 | +16.8 | |
| | .780 | +23.5 | |
| | .799 | +14.9 | |
| | .817 | + 1.0 | |
| | .837 | - 3.9 | Good plate. |
| | .858 | - 8.4 | |
| | .883 | +25.7 | |
| April 25..... | 535.702 | +72.5 | Poor plate. |
| | .745 | +36.1 | |
| | .765 | +12.9 | |
| | .784 | -10.1 | |
| | .833 | -18.9 | Poor plate. |
| | .858 | - 6.9 | |
| | .883 | +47.1 | Thin plate. |
| April 26..... | 536.739 | +24.5 | |
| | .767 | +33.5 | |
| | .797 | + 7.0 | |

RADIAL VELOCITIES OF σ SCORPII—*Continued*

| Date | Julian Day | Velocity km. | Remarks |
|--------------------|-------------|-----------------|------------------|
| 1923 April 29..... | 2423539.704 | - 1.5 | |
| | .730 | + 4.0 | |
| | .753 | -13.9 | |
| May 1..... | 541.703 | - 8.0 | |
| | .726 | -16.7 | |
| | .749 | -18.9 | |
| | .770 | -21.7 | |
| | .790 | -11.9 | |
| | .811 | + 5.4 | |
| | .833 | +19.2 | |
| | .858 | +38.0 | |
| May 2..... | 542.660 | - 0.9 | Poor plate. |
| | .715 | -25.4 | |
| | .733 | -24.6 | |
| | .751 | -15.3 | |
| | .769 | -10.5 | |
| | .787 | - 7.5 | Dense plate. |
| | .806 | + 4.1 | |
| | .826 | + 1.3 | Poor plate. |
| May 4..... | 544.706 | -28.7 | Poor plate. |
| | .728 | -26.8 | Poor plate. |
| | .753 | -13.9 | |
| | .778 | - 6.3 | |
| | .802 | +11.5 | Thin plate. |
| | .828 | +24.9 | |
| May 5..... | 545.708 | -36.5 | |
| | .727 | -18.4 | |
| | .745 | -14.5 | |
| | .763 | +17.4 | Very poor plate. |
| | .781 | +22.6 | |
| | .800 | +44.3 | |
| | .821 | +25.0 | Thin plate. |
| May 6..... | 546.699 | -29.3 | |
| | .719 | -17.9 | |
| | .740 | - 7.8 | |
| | .760 | +11.5 | |
| | .781 | +21.8 | |
| | .803 | +38.5 | Thin plate. |
| May 9..... | 549.700 | - 9.9 | Thin plate. |
| | .722 | - 8.9 | |
| | .744 | +14.9 | Poor plate. |
| | .767 | +31.1 | |
| May 10..... | 550.656 | -38.9 | |
| | .697 | - 9.3 | |
| | .715 | - 0.3 | |
| | .769 | +17.4 | |
| May 13..... | 553.655 | -22.5 | |
| | .677 | - 3.1 | |
| | .698 | + 2.9 | |
| | .719 | +26.6 | |
| | .740 | +29.3 | Poor plate. |
| | .760 | - 3.9 | Thin plate. |
| | .782 | -27.0 | |
| | .806 | -25.2 | Thin plate. |

RADIAL VELOCITIES OF σ SCORPII—*Continued*

| Date | Julian Day | Velocity km. | Remarks |
|-------------------|-------------|-----------------|------------------|
| 1923 May 14..... | 2423554.680 | + 3.7 | Thin plate. |
| | .704 | +16.6 | |
| May 17..... | 557.791 | -67.4 | Very poor plate. |
| May 18..... | 558.684 | +17.2 | |
| | .710 | -18.1 | |
| May 21..... | 561.636 | +36.9 | Thin plate |
| | .668 | -31.3 | |
| | .694 | -35.0 | |
| | .716 | -43.0 | |
| | .736 | -44.4 | Thin plate. |
| | .756 | -54.5 | |
| | .778 | -26.7 | |
| May .22..... | 562.609 | +38.1 | |
| | .664 | -13.2 | |
| | .684 | -29.6 | |
| | .703 | -35.3 | |
| | .724 | -52.2 | |
| | .745 | -48.4 | |
| | .767 | -27.6 | |
| | .791 | -22.8 | |
| 1924 Mar. 31..... | 876.771 | - 8.4 | |
| | .794 | +21.4 | |
| | .819 | +46.3 | |
| | .844 | +37.0 | |
| | .867 | - 6.8 | |
| April 4..... | 880.759 | +20.6 | |
| | .788 | +41.6 | |
| April 9..... | 885.801 | -58.4 | |
| | .819 | -61.0 | |
| | .836 | -57.8 | |
| | .853 | -56.6 | |
| | .869 | -40.8 | |
| April 10..... | 886.751 | -27.9 | |
| | .777 | -45.2 | |
| | .802 | -57.8 | |
| | .826 | -53.8 | |
| | .849 | -61.8 | |
| | .872 | -34.4 | |
| | .894 | -24.7 | |
| April 11..... | 887.730 | -36.5 | |
| April 14..... | 890.756 | -53.3 | |
| | .780 | -54.5 | |
| | .810 | -26.9 | |
| | .837 | - 4.1 | |
| | .866 | - 6.3 | |
| April 15..... | 891.733 | -67.2 | |
| | .759 | -66.1 | |
| | .783 | -27.0 | |
| | .807 | -14.1 | |
| | .831 | - 3.1 | |
| | .858 | + 4.7 | |
| | .885 | +29.4 | |
| April 16..... | 892.729 | -47.8 | |
| | .759 | -30.3 | |
| | .786 | -17.4 | |

RADIAL VELOCITIES OF σ SCORPII—Continued

| Date | Julian Day | Velocity km. | Remarks |
|--------------------|-------------|-----------------|---------|
| 1924 April 16..... | 2423892.813 | +20.9 | |
| | .840 | +19.0 | |
| | .870 | +15.1 | |
| April 19..... | 895.728 | - 9.6 | |
| | .753 | - 8.5 | |
| | .776 | +14.4 | |
| | .797 | +41.8 | |
| | .817 | +36.1 | |
| | .837 | +24.6 | |
| | .859 | +23.0 | |
| | .881 | + 4.7 | |
| April 20..... | 896.854 | +37.0 | |
| | .879 | +10.4 | |
| April 23..... | 899.720 | +27.7 | |
| | .747 | +54.7 | |
| | .773 | +87.9 | |
| | .797 | +55.2 | |
| | .820 | +23.5 | |
| | .844 | +29.5 | |
| | .867 | + 5.6 | |
| April 24..... | 900.794 | +25.9 | |
| | .814 | +17.4 | |
| | .834 | 0.0 | |
| | .854 | - 0.9 | |
| April 25..... | 901.841 | - 1.6 | |
| | .862 | - 7.2 | |
| April 26..... | 902.709 | +37.3 | |
| | .728 | +52.2 | |
| | .747 | +67.8 | |
| | .765 | +49.1 | |
| | .785 | +19.0 | |
| | .806 | + 1.8 | |
| | .827 | - 7.6 | |
| | .849 | - 7.7 | |
| | .874 | -17.0 | |
| April 28..... | 904.727 | +60.5 | |
| | .822 | -12.9 | |
| May 2..... | 908.701 | - 4.6 | |
| | .726 | - 9.5 | |
| | .748 | -12.6 | |
| | .768 | -32.0 | |
| | .789 | -28.2 | |
| | .810 | -19.7 | |
| | .833 | -12.4 | |
| | .858 | +12.4 | |
| May 4..... | 910.716 | -15.0 | |
| | .738 | -42.7 | |
| | .759 | -39.7 | |
| | .780 | -24.9 | |
| | .801 | -27.4 | |
| May 5..... | 911.699 | -13.8 | |
| | .719 | -26.5 | |
| | .743 | -42.0 | |
| May 6..... | 912.700 | -31.7 | |
| | .721 | -43.0 | |

RADIAL VELOCITIES OF σ SCORPII—Continued

| Date | Julian Day | Velocity km. | Remarks |
|-----------------|-------------|-----------------|---------|
| 1924 May 6..... | 2423912.741 | -43.6 | |
| | .760 | -49.7 | |
| | .778 | -23.3 | |
| | .800 | - 4.3 | |
| | .823 | +12.9 | |
| May 8..... | 914.751 | -36.1 | |
| | .775 | -14.2 | |
| | .802 | + 0.4 | |
| May 11..... | 917.717 | -25.8 | |
| | .774 | - 3.6 | |
| May 16..... | 922.785 | -17.3 | |
| | .806 | -22.7 | |
| May 18..... | 924.671 | + 3.1 | |
| | .690 | +14.6 | |
| | .704 | +23.0 | |
| | .718 | +13.6 | |
| | .732 | + 8.4 | |
| | .746 | - 3.6 | |
| | .760 | -16.5 | |
| | .775 | -26.3 | |
| May 19..... | 925.619 | -16.5 | |
| | .659 | + 8.7 | |
| | .677 | +14.4 | |
| | .688 | +24.9 | |
| | .700 | +23.4 | |
| | .710 | +23.8 | |
| | .731 | -11.9 | |
| | .744 | -19.1 | |
| May 20..... | 926.667 | +22.1 | |
| | .685 | +28.8 | |
| | .696 | +30.1 | |
| | .707 | + 8.9 | |
| | .719 | - 1.4 | |
| | .730 | + 6.3 | |
| | .742 | -12.7 | |
| | .756 | - 9.5 | |
| May 22..... | 928.623 | +46.6 | |
| | .663 | +72.6 | |
| | .706 | + 2.5 | |
| | .726 | -18.6 | |
| May 25..... | 931.716 | - 9.0 | |
| | .733 | - 9.2 | |
| | .751 | + 0.8 | |
| | .769 | + 0.8 | |
| May 29..... | 935.598 | +14.2 | |
| | .622 | + 4.7 | |
| | .660 | + 2.3 | |
| | .677 | + 2.6 | |
| | .742 | +17.2 | |
| | .767 | +33.6 | |
| | .794 | +29.2 | |
| May 30..... | 936.633 | - 6.2 | |
| | .657 | - 8.7 | |
| | .678 | -20.7 | |
| | .699 | - 0.4 | |

RADIAL VELOCITIES OF σ SCORPII—Continued

| Date | Julian Day | Velocity km. | Remarks |
|--------------------|-------------|-----------------|---------|
| 1924 May 30..... | 2423936.718 | + 1.3 | |
| | .738 | +13.3 | |
| | .760 | +25.5 | |
| June 3..... | 940.585 | -14.9 | |
| | .613 | -34.6 | |
| | .660 | -19.3 | |
| | .685 | + 5.3 | |
| June 5..... | 942.583 | -25.8 | |
| | .612 | -21.3 | |
| | .665 | +12.7 | |
| | .690 | +12.4 | |
| | .716 | +12.1 | |
| June 8..... | 945.614 | -27.4 | |
| | .658 | +10.3 | |
| | .676 | +27.9 | |
| | .697 | +29.9 | |
| | .721 | +13.2 | |
| | .747 | -12.7 | |
| June 9..... | 946.630 | + 3.6 | |
| | .651 | +20.8 | |
| | .674 | +37.8 | |
| | .690 | +29.3 | |
| | .706 | + 4.4 | |
| | .723 | + 2.7 | |
| | .744 | -15.2 | |
| | .771 | -48.8 | |
| June 10..... | 947.604 | - 1.4 | |
| June 13..... | 950.601 | +13.8 | |
| | .617 | +15.3 | |
| | .677 | -23.6 | |
| | .703 | -42.5 | |
| June 16..... | 953.569 | - 0.4 | |
| | .592 | +25.3 | |
| | .612 | +17.8 | |
| | .650 | -27.4 | |
| | .669 | -35.6 | |
| | .689 | -52.5 | |
| | .709 | -40.6 | |
| June 18..... | 955.564 | +19.0 | |
| | .584 | +26.0 | |
| | .599 | - 8.8 | |
| 1920 April 13..... | 2422428.772 | -49.8 | |
| | .789 | -53.8 | |
| | .804 | -39.6 | |
| | .820 | -34.9 | |
| | .834 | -35.2 | |
| | .846 | -22.8 | |
| April 16..... | 431.727 | -41.7 | |
| | .769 | -62.8 | |
| | .785 | -51.6 | |
| | .804 | -58.3 | |
| | .826 | -55.0 | |
| April 18..... | 433.712 | -51.7 | |
| | .773 | -47.2 | |
| | .799 | -43.4 | |

RADIAL VELOCITIES OF σ SCORPII—*Concluded*

| Date | Julian Day | Velocity km. | Remarks |
|--------------------|-------------|-----------------|------------|
| 1920 April 18..... | 2422433.822 | -22.7 | |
| April 19..... | 434.724 | -47.2 | Poor plate |
| | .777 | -37.0 | |
| | .800 | -20.1 | Poor plate |
| | .833 | + 0.6 | Very poor |
| April 25..... | 440.713 | -19.2 | |
| | .768 | +17.9 | |
| | .788 | +25.2 | |
| | .813 | - 7.4 | |
| | .838 | -25.7 | Poor |
| May 4..... | 449.684 | +29.6 | Poor |
| | .707 | + 8.8 | |
| | .729 | - 4.3 | Poor |
| | .760 | -23.8 | |
| | .783 | -22.7 | |
| | .811 | - 9.9 | Very poor |
| May 5..... | 450.683 | + 6.1 | |
| | .707 | + 6.1 | |
| | .729 | + 4.5 | |
| | .768 | -12.0 | Poor |
| | .792 | -10.8 | |
| | .817 | + 5.0 | Very weak |
| May 10..... | 455.676 | -32.8 | |
| | .699 | -34.0 | |
| | .722 | -29.1 | Weak |
| | .767 | -16.4 | |
| May 11..... | 456.673 | -31.1 | |
| | .696 | -37.7 | |
| | .718 | -38.5 | |
| | .764 | - 7.4 | |
| | .786 | +25.9 | Very poor |
| | .811 | +10.7 | Very poor |

The above velocities furnish a fairly large number of nearly complete velocity curves which may be considered, within the limits of error, of constant amplitude. Their center-of-mass lines, if they might be called so, give the following velocities for the nights indicated.

VALUES OF CENTER-OF-MASS VELOCITY DEDUCED FROM SHORT-PERIOD CURVES

| Date | Julian Day | Velocity km. | Date | Julian Day | Velocity km. |
|-------------------|------------|-----------------|------------------|------------|-----------------|
| 1920 April 13.... | 2422428.8 | -12 | 1924 Mar. 31.... | 2423876.8 | + 5 |
| “ 16.... | 431.8 | -23 | April 9.... | 885.7 | -22 |
| “ 18.... | 433.8 | -20 | “ 10.... | 886.7 | -22 |
| “ 19.... | 434.8 | -20 | “ 14.... | 890.9 | -15 |
| “ 25.... | 440.8 | -18 | “ 15.... | 891.9 | -15 |
| May 4.... | 449.7 | +18 | “ 16.... | 892.9 | - 6 |
| “ 5.... | 450.7 | +23 | “ 19.... | 895.8 | + 8 |
| “ 10.... | 455.7 | + 3 | “ 20.... | 896.8 | +22 |
| “ 11.... | 456.8 | + 2 | “ 23.... | 899.8 | +35 |
| 1923 April 9.... | 2423519.9 | -18 | “ 24.... | 900.8 | +30 |
| “ 11.... | 521.9 | -18 | “ 25.... | 901.8 | +32 |
| “ 13.... | 523.8 | -26 | “ 26.... | 902.7 | +24 |
| “ 14.... | 542.8 | -28 | “ 28.... | 904.7 | +22 |
| “ 17.... | 527.8 | -22 | May 2.... | 908.9 | + 8 |
| “ 18.... | 528.8 | -18 | “ 4.... | 910.6 | + 2 |
| “ 23.... | 533.8 | +28 | “ 5.... | 911.6 | - 2 |
| “ 24.... | 534.8 | +32 | “ 6.... | 912.9 | - 7 |
| “ 25.... | 535.8 | +24 | “ 8.... | 914.8 | -12 |
| “ 26.... | 536.8 | +32 | “ 18.... | 924.7 | -15 |
| “ 29.... | 539.7 | +16 | “ 19.... | 925.7 | -15 |
| May 1.... | 541.8 | +11 | “ 20.... | 926.7 | - 7 |
| “ 2.... | 542.8 | + 8 | “ 22.... | 928.7 | +13 |
| “ 4.... | 544.8 | 0 | “ 25.... | 931.6 | +32 |
| “ 5.... | 545.8 | + 2 | “ 29.... | 935.6 | +31 |
| “ 6.... | 546.8 | + 1 | “ 30.... | 936.8 | +22 |
| “ 9.... | 549.7 | -11 | June 3.... | 940.8 | +10 |
| “ 10.... | 550.7 | -12 | “ 5.... | 942.7 | +10 |
| “ 13.... | 553.8 | -15 | “ 8.... | 945.7 | - 8 |
| “ 14.... | 554.7 | -22 | “ 9.... | 946.7 | -10 |
| “ 18.... | 558.7 | -24 | “ 13.... | 950.6 | -20 |
| “ 21.... | 561.7 | -16 | “ 16.... | 953.6 | -20 |
| “ 22.... | 562.7 | -13 | “ 18.... | 955.6 | -19 |

The velocities of 1923-24 furnish very good curves of radial velocity variation of the centre of mass. It is found, however, that the new velocities of 1920 indicate a curve of larger amplitude than that previously found; also it is considered that the velocities of 1920 and 1921 are too few to determine curves with certainty. The different curves of 1918-20-21-22-23-24 are given in Fig. 1. The curve of 1918 has been redetermined from new values of centre-of-mass velocities derived from the Lick original measures; these new values were obtained in exactly the same way as the more recent Ottawa values.

A considerable variation of the amplitude of these curves is doubtful, but the fact remains that there is some variation of shape and amplitude which is apparently due to the perturbations of a third body. Indeed it is clearly shown that the centre-of-mass velocity of these different curves varies, a strong indication of a revolution in an orbit of a period of several years.

SIGMA SCORPII.

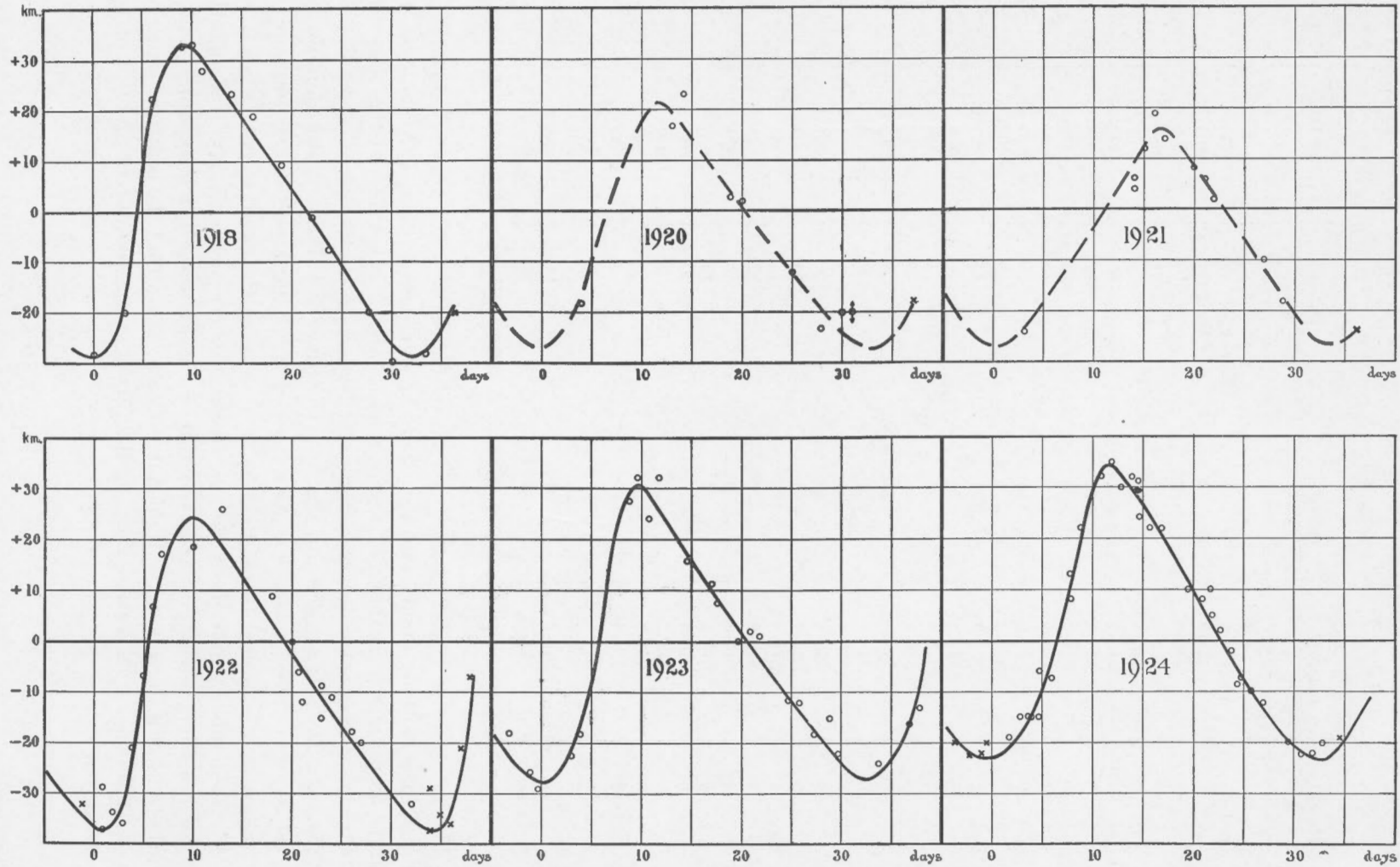


Fig. 1—Radial Velocity Variation of Center of Mass

The period connecting the different minima of the long-period curves from 1915 to 1924 is now found to be $33^d.0$. The observed value of the very short period of velocity variation does not appear to be constant; this may, however, be explained on the assumption that the true period is constant but appears variable by reason of the displacement of the body in an orbit of several years' period, so that the observed times of maximum and minimum require correction for equation of light. The true very short period cannot be computed exactly until we know more about the very long-period orbit, but if we adopt as origin the date of maximum J. D. 2420644.830 and the period $0^d.246834$ the following tables give the observed and computed times of maxima and the residuals obtained. The mean of the residuals of each year is given at the bottom of each table.

MAXIMA OF SHORT-PERIOD VELOCITY CURVES

| Observed | Computed | O-C | Observed | Computed | O-C |
|-------------|----------|-------|-------------|----------|----------|
| 1915 | | | 1921 | | |
| 2420644.829 | .830 | -.001 | 2422813.742 | .760 | -.018 |
| 671.728 | .734 | - 6 | 815.694 | .735 | - 41 |
| 674.688 | .696 | - 8 | 819.630 | .684 | - 54 |
| 701.600 | .602 | - 2 | 820.636 | .672 | - 36 |
| | | | 821.622 | .659 | - 37 |
| | | -.004 | 826.819 | .843 | - 24 (?) |
| 1918 | | | 828.841 | .817 | + 24 |
| 2421687.950 | .950 | .000 | 835.692 | .729 | - 37 |
| 688.933 | .937 | - 4 | 846.578 | .589 | - 11 |
| 695.968 | .968 | 0 | 847.552 | .577 | - 25 |
| 699.918 | .917 | + 1 | 849.536 | .551 | - 15 |
| 701.900 | .892 | + 8 | | | -.025 |
| 705.840 | .841 | - 1 | 1922 | | |
| 707.950 | .944 | + 6 | 2423147.930 | .974 | -.044 |
| 713.860 | .867 | - 7 | 149.930 | .948 | - 18 |
| 716.955 | .948 | + 7 | 150.897 | .936 | - 39 |
| 719.916 | .911 | + 5 | 152.875 | .910 | - 35 |
| 724.850 | .848 | + 2 | 161.773 | .796 | - 23 |
| 726.821 | .822 | - 1 | 163.741 | .771 | - 30 |
| | | +.001 | 166.940 | .980 | - 40 |
| 1920 | | | 168.915 | .954 | - 39 |
| 2422428.672 | .699 | -.027 | 169.885 | .942 | - 57 |
| 431.655 | .661 | -.005 | 172.882 | .904 | - 22 |
| 433.626 | .636 | -.010 | 175.855 | .866 | - 11 |
| 434.864 | .870 | -.006 | 183.728 | .765 | - 37 |
| 440.776 | .794 | -.018 | 185.716 | .739 | - 23 |
| 449.653 | .680 | -.027 | 186.690 | .727 | - 37 |
| 450.650 | .668 | -.018 | 188.665 | .701 | - 36 |
| 455.844 | .851 | -.007 | 189.650 | .689 | - 39 |
| 456.830 | .838 | -.008 | 196.798 | .847 | - 49 |
| | | -.014 | 197.798 | .834 | - 36 |
| | | | 198.781 | .821 | - 40 |
| | | | 200.770 | .796 | - 26 |
| | | | | | -.034 |

MAXIMA OF SHORT-PERIOD VELOCITY CURVES

| Observed | Computed | O-C. | Observed | Computed | O-C. |
|-------------|----------|--------|-------------|----------|--------|
| | 1923 | | | 1924 | |
| 2423519.910 | .952 | -.042 | 2423876.831 | .874 | -.043 |
| 521.885 | .927 | - 42 | 885.955 | .007 | - 52 |
| 523.860 | .902 | - 42 | 886.703 | .748 | - 45 |
| 524.846 | .889 | - 43 | 890.900 | .944 | - 44 |
| 527.809 | .851 | - 42 | 891.875 | .931 | - 56 |
| 528.805 | .838 | - 33 | 892.854 | .919 | - 65 |
| 534.718 | .762 | - 44 | 895.830 | .881 | - 51 |
| 535.705 | .750 | - 45 | 899.780 | .830 | - 50 |
| 541.876 | .921 | - 45 | 902.746 | .792 | - 46 |
| 542.865 | .908 | - 43 | 908.665 | .716 | - 51 |
| 544.837 | .883 | - 46 | 910.639 | .691 | - 52 |
| 545.820 | .870 | - 50 | 912.863 | .912 | - 49 |
| 546.813 | .857 | - 44 | 924.713 | .760 | - 47 |
| 549.775 | .819 | - 44 | 925.695 | .748 | - 53 |
| 550.764 | .807 | - 43 | 926.691 | .735 | - 44 |
| 553.727 | .769 | - 42 | 928.649 | .709 | - 60 |
| 558.662 | .705 | - 43 | 935.567 | .621 | - 54 |
| 561.620 | .667 | - 47 | 936.808 | .855 | - 47 |
| 562.615 | .655 | - 40 | 940.754 | .817 | - 63 |
| | | | 942.748 | .792 | - 44 |
| | | - .043 | 945.696 | .741 | - 45 |
| | | | 946.680 | .728 | - 48 |
| | | | 950.625 | .678 | - 53 |
| | | | 953.600 | .640 | - 40 |
| | | | | | - .050 |

These residuals show a variation of the equation of light from year to year. If, however, the maxima of radial velocity of 1915 had been shifted by about one hour through some errors of observation, one might find an approximately constant period which would give no such variation. Such a shift, however, (about one-sixth of the period) does not seem probable, and since the series of 33-day period curves indicate the existence of an orbit of several years' period, an effect depending on the equation of light is to be expected in the six-hour period.

It is to be remarked that a circular orbit of twelve years' period with a semi-amplitude of radial velocity variation of about 10 km. would give a value of $a \sin i$ of the same order of magnitude as that of an equation of light of $0^d.05$. We have, approximately, from the spectroscopic orbit

$$a \sin i = 602,293,800 \text{ km.}$$

and from the equation of light

$$a \sin i = 648,000,000 \text{ km.}$$

The parallax of σ Scorpii is no doubt very small; according to Professor Kapteyn, as obtained from star-streaming, it is $0''.0086$ (Boss 4158)¹. The apparent radius of a visual twelve-year period orbit would be approximately $0''.04$, a quantity impossible to detect by direct measurement, unless perhaps by interferential methods.

¹ Contributions from the Mt. Wilson Observatory, Vol. 4, p. 417.

SIGMA SCORPII

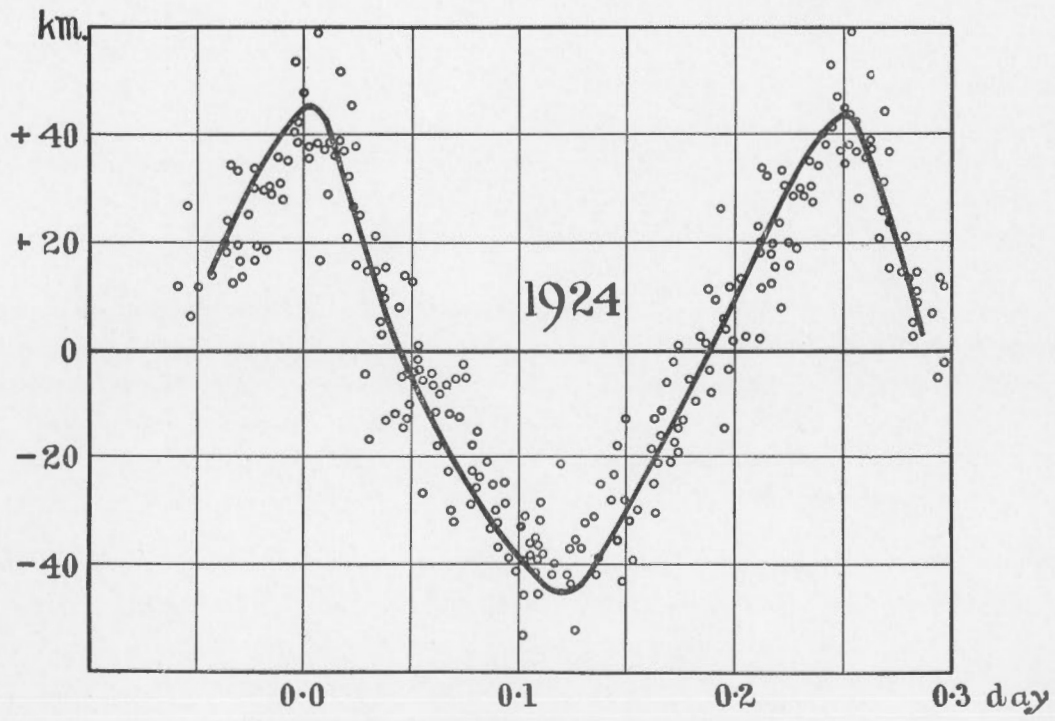
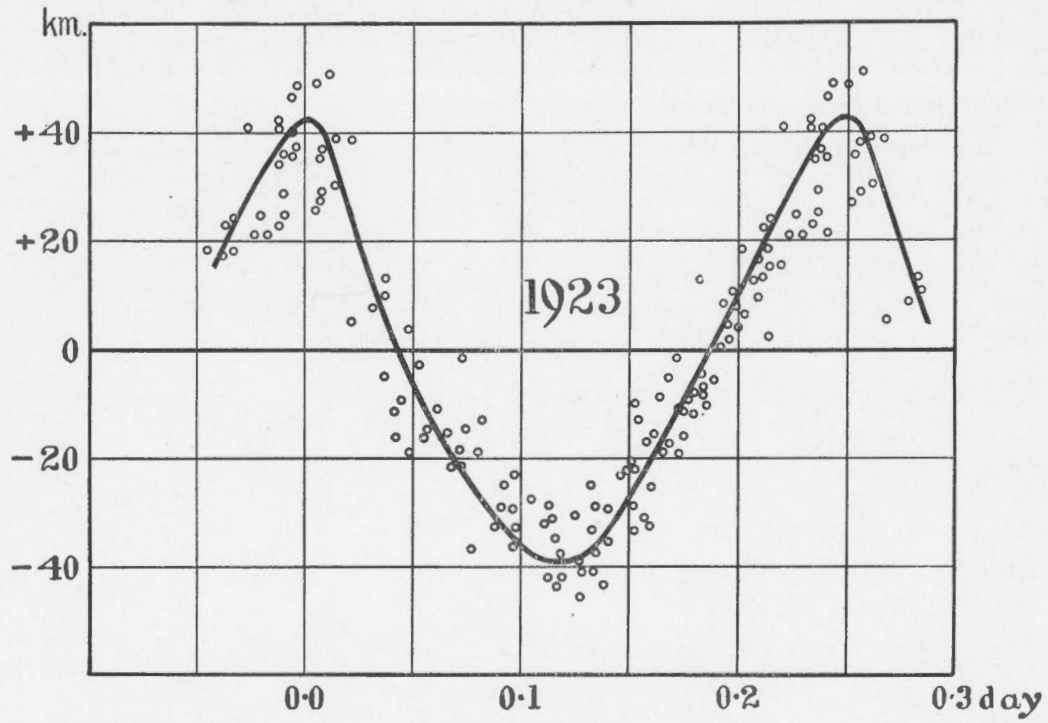


Fig. 2—Short Period Velocity Curve

Taking the two groups of observations of 1923 and 1924 one may superpose for each group the different short-period velocity curves so that all of them have the same but undetermined mean velocity. This furnishes the curves shown in Fig. 2.

DOMINION OBSERVATORY, OTTAWA
September 10, 1924.

