ASTROMETRY WITH THE YALE HELIOMETER, 1882-1910

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In 1880 Yale ordered a 6-inch heliometer from Repsold of Hamburg which was delivered on time for observations of the transit of Venus in 1882. Stellar astrometry, however, was not begun until W. L. Elkin came to Yale in 1884. Trained at Strassburg his Ph.D. dissertation dealt with the parallax of α Centauri (Elkin 1880). He then gained practical experience with Sir David Gill at the Cape. Elkin was the ideal man for the Yale heliometer and to secure his appointment H. A. Newton (1884) solicited subscriptions of $100 per year for three years from ten officers and friends of the observatory.

Elkin's first use of the heliometer (Elkin 1887) was the re-measurement of the relative positions of stars in the Pleiades that had previously been observed by Bessel with the famous Koenigsberg heliometer about a century before. Among the 69 stars measured nine proved to be non-members of the cluster. He compared his results with measurements by Gould of Rutherfurd's wet-plate photographs, and with plates taken later with the 36-inch at Lick. He found that the heliometer observations were superior for the bright stars, which were over-exposed on the Lick photographs, and that the agreement for stars fainter than 7th magnitude was excellent. Already in 1889 he was impressed with the advantages of photography over visual methods, especially in time-saving (Elkin 1889).

Among the various projects Elkin undertook with the heliometer were the measurement of the positions of stars within one degree of the north pole, at the request of E. C. Pickering of Harvard, to serve as a fundamental reference frame for a photographic catalogue; positions of the moon relative to surrounding stars; diameters of Venus; measurements of Titan for the determination of the mass of Saturn, and of Jupiter's satellites for the determination of their orbits and the mass of Jupiter; and measurements of asteroids for the determination of the solar parallax.

S. Débarbat et al. (eds.), Mapping the Sky, 123–128.

In collaboration with observatories world-wide, but especially with Gill (1897) at the Cape, a value of 8".802 ±".005 was determined, the modern value being 8".794.

At first, like Gill (Gill and Elkin 1884), Elkin was more interested in getting a good average parallax for the bright stars, as the probable errors of the individual stars were large, generally about ±".047 (Elkin 1888). However, the dispersion of the individual parallaxes published in 1902 turned out to be great, the values ranging from -".012 for Deneb to +".334 for Sirius among the ten brightest northern stars, with errors now reduced to ".014 to ".024. Hence he abandoned the determination of a mean parallax for each magnitude group and shifted his attention to stars of large proper motion. He proposed making only a limited number of observations on each star, then to observe more extensively only those most promising for proximity.

In 1910 Elkin found it necessary to retire because of poor health. The work continued under his faithful assistants, F. L. Chase and M. F. Smith, and their final catalogue of 244 stars was published in 1912 (Elkin *et. al.* 1912). This represented two thirds of all the 365 parallaxes determined up to that time. The probable errors of unit weight (approximately ±".10 to ±".20) showed no systematic correlations with stellar magnitude, spectral type, declination, or proper motion of the stars observed, nor with the sizes of their modern parallaxes. Frank Schlesinger, known as "the father of modern astrometry," said of the work of Elkin and his associates, "These results constitute by far the most important single contribution to our knowledge of stellar distances up to that time" (Schlesinger 1937). It is of interest to see just how good they are relative to other determinations.

One hundred of the stars already had parallaxes determined by other methods than with a heliometer: 8 by filar micrometer, 83 with a transit instrument, 39 by photography and 3 by spectrograph. In addition, parallaxes for 13 had been determined with other heliometers. The various comparisons indicate generally good systematic agreement, but larger dispersions than their individual quoted probable errors would suggest.

A comparison of the Yale heliometer results with the most recent values available in the current compilation of stellar trigonometric parallaxes (van Altena 1987) confirms the overall accuracy of the early determinations. The probable error of a single difference (photographic *minus* heliometer) is ±".029 for Elkin, ±".025 for Chase (who contributed the largest number of observations), and ±".028 for Smith, including all the heliometer determinations. For those depending on 40 or more heliometer observations

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the errors were reduced to ±".019. This compares well with the probable error of about ±".015 for the difference between any two modern photographic determinations given in the *Supplement to the General Catalogue of Trigonometric Parallaxes* (Jenkins 1963).

An HR diagram based on the Yale heliometer parallax determinations (Figure 1) compares favorably with the classical earlier results by Hertzsprung (1907) and Russell (1914). Hertzsprung himself never published any such diagram but when he first discovered that stars of the same color could differ greatly in intrinsic luminosity he did publish the data from which the diagram could be plotted (see Hoffleit 1950). This does not show the giant and dwarf sequences as clearly as the more famous diagram published later by Russell.

Finally, Figure 2 shows the rate of growth of stellar parallax determinations from 1838 to the present. By 1910 the Yale heliometer had contributed the greatest numbers; then Schlesinger carried on the tradition photographically. The curve levels off significantly after 1941 when Schlesinger retired as the Director of the Yale Observatory.

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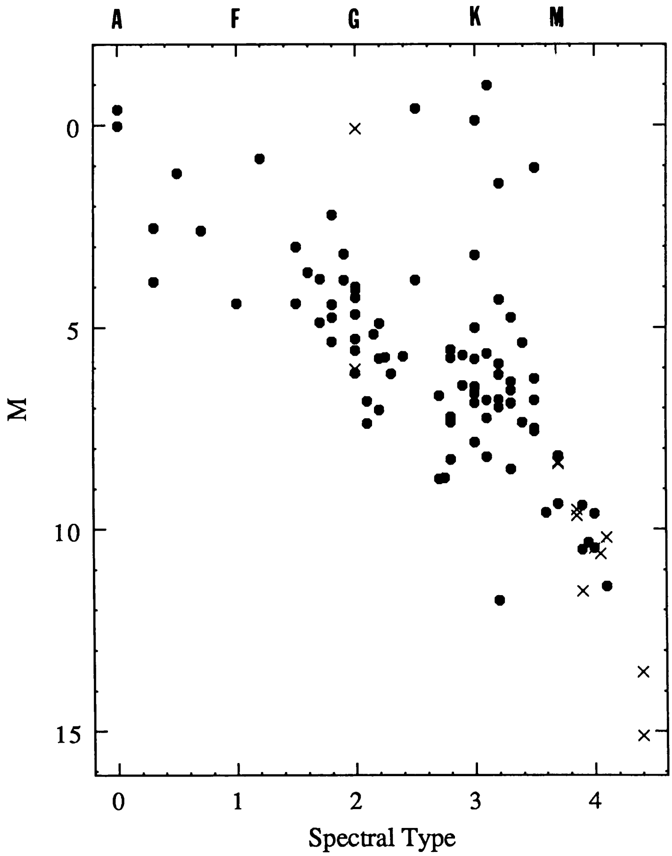

Figure 1 - HR diagram based on Yale heliometer determinations of parallaxes greater than twice their probable errors. Crosses for companions of the parallax stars. Numbers at bottom, numerical codes for spectral class.

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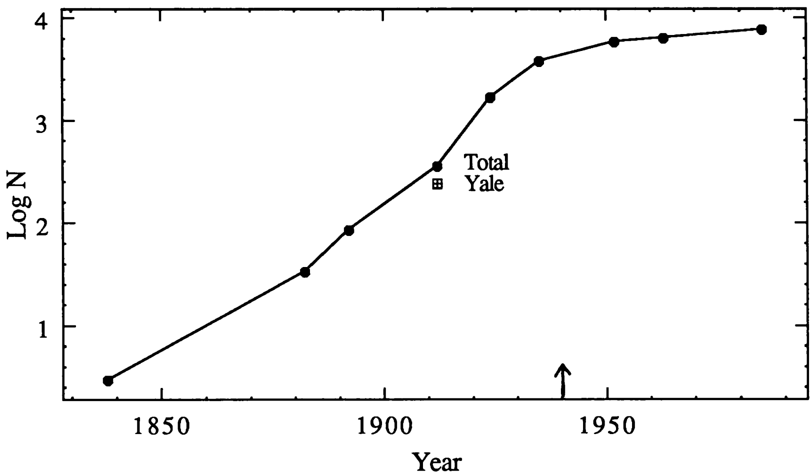

Figure 2 - Rate of increase in the number of trigonometric parallax determinations from 1838 to the present. By 1910 two thirds of the known parallaxes had been determined at Yale (244 out of 365). The rate of increase declined after the retirement of Schlesinger in 1941.

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