SYSTEMATIC DIFFERENCES IN TRIGONOMETRIC PARALLAXES FROM DIFFERENT OBSERVATORIES

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ABSTRACT

Systematic differences in trigonometric parallaxes between Allegheny Observatory and Yale Observatory, between Allegheny Observatory and McCormick Observatory and between the Cape Observatory and Yale Observatory have been investigated for stars common to each pair. The differences found correlate with right ascension, naturally suggesting some sort of annual influence. It is proposed that these differences are related to differences in the annual temperature cycle between observatories, possibly through the mechanism of temperature dependent decentering of the telescope objectives. A dependence upon spectral type was also discovered in the differences between the relative parallaxes from Allegheny and from Yale. Further work is needed to clarify the nature of these systematic effects and to insure that they do not significantly bias available trigonometric parallaxes.

It is proposed that a new parallax catalogue be constructed at Yale after a thorough statistical analysis of all available trigonometric parallaxes has been made. We solicit suggestions and recommendations from interested users.

I. INTRODUCTION

It has long been remarked that trigonometric parallaxes derived for stars common to the programs of several observatories show small systematic differences from one observatory to another. Particularly pronounced are the differences between parallaxes from northern hemisphere observatories and from those of the southern hemisphere, which amount to about 0\".005 (Strand, 1971). Though

C. Jaschek and G. A. Wilkins (eds.), Compilation, Critical Evaluation, and Distribution of Stellar Data. 183-189.

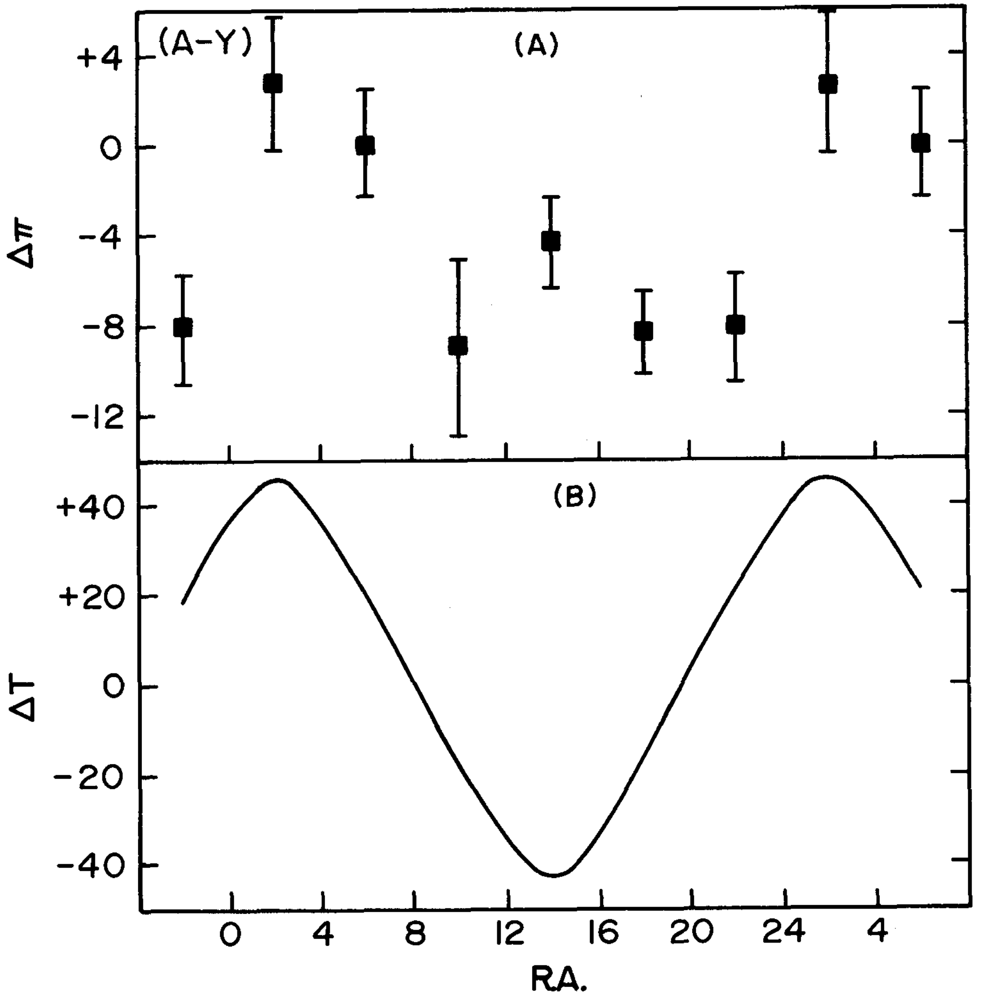

Figure 1. (A) The (A-Y) parallax differences in units of 0.001 arc-sec as a function of the right ascension. (B) The difference in temperature range, evening minus morning, between Pittsburg and Johannesburg as a function of the right ascension.

some proposals have been advanced (e.g. Atkinson, 1971) the cause of these differences has yet to be established. This paper explores in a preliminary manner some of the systematic effects between parallaxes from two northern sites, Allegheny and McCormick and from two southern sites, Yale and the Cape.

We also propose to construct a new Parallax Catalogue after a thorough statistical analysis of all available trigonometric parallaxes. We solicit suggestions from interested users.

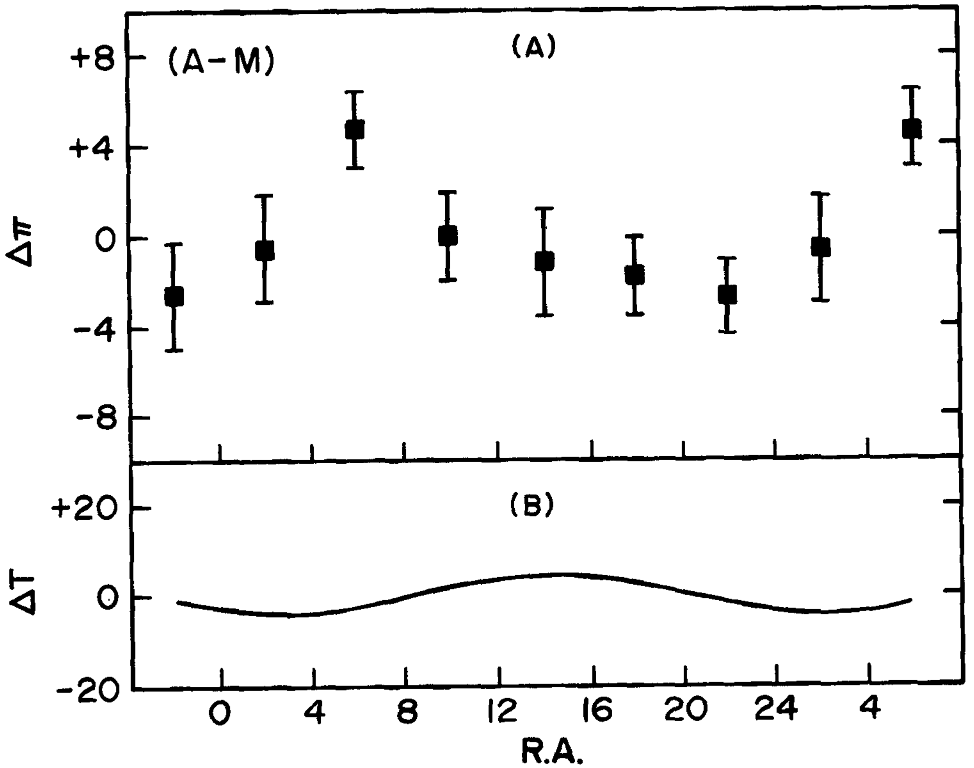

Figure 2. (A) The (A-M) parallax differences in units of 0.001 arc-sec as a function of the right ascension. (B) The difference in temperture range, evening minus morning, between Pittsburg and Richmond as a function of the right ascension.

II. DATA

The data for these comparisons are the relative parallaxes for 295 stars common to the programs of Allegheny and Yale, 499 stars common to the Cape and Yale programs, and for 680 stars common to the Allegheny and McCormick progroms. These were obtained from the General Catalogue of Trigonometric Stellar Parallaxes (Jenkins,1952). Differences were computed in the sense Allegheny minus Yale, Cape minus Yale and Allegheny minus McCormick from the relative parallaxes of the common stars.

III. RESULTS

The mean differences were, Allegheny minus Yale, -0"005, Cape minus Yale, -0"002, and Allegheny minus McCormick, -0"001. An interesting result is obtained, however, if instead of looking at

https://doi.org/10.1017/S0252921100053070 Published online by Cambridge University Press

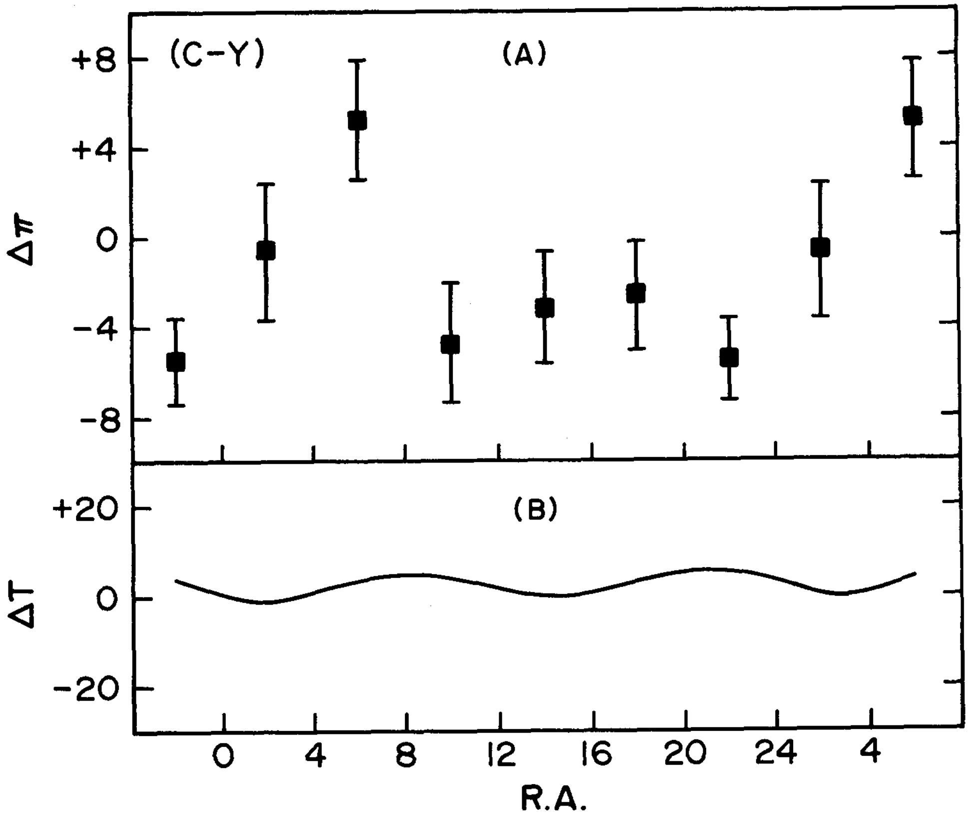

Figure 3. (A) The (C-Y) parallax differences in units of 0.001 arc-sec as a function of the right ascension. (B) The difference in temperature range, evening minus morning, between Capetown and Johannesburg as a function of the right ascension.

the mean difference of all of the parallaxes we divide the stars into groups by right ascension. Figures 1a, 2a, and 3a plot the differences (A-Y), (A-M) and (C-Y) for the stars in bins spanning four hour zones of right ascension. The differences (A-Y), (C-Y) and perhaps (A-M) seem to correlate with right ascension. Similar systematic errors in right ascension have been pointed out by van Maanen (1933), Mitchell (1934), Davidson (1934), Sterne (1935), Dahlgren (1960), and Ljunggren and Oja (1965).

Since the photographic plates from which these parallaxes were determined were taken near the meridian the association of mean difference with right ascension suggests an annual effect. Some sort of optical effect must be present, more likely in the telescope than in the atmosphere since we are dealing with parallax differences, and moreover, with x parallaxes which should not be especially

https://doi.org/10.1017/S0252921100053070 Published online by Cambridge University Press

sensitive to seasonal changes of the air. A plausible seasonal influence is the annual cycle of temperature variation (Davidson 1934). Evening and morning plates are taken at different times of the year for a given star, and consequently at different average temperatures and temperature gradients. It is conceivable that this temperature variation could alter the optical properties of the telescope (see for example, Ianna[1965] and Kamper [1971]) between the taking of morning and evening plates for each bin of right ascension.

To test this hypothesis mean monthly temperatures for Pittsburg (Allegheny), Richmond (McCormick), Johannesburg (Yale) and Capetown (Cape) were obtained from Nelson (1968). Estimates were then made of the range of temperature between the taking of the evening and morning plates for each bin of right ascension and for each observatory. Because we are interested in differential effects, the differences between the ranges for Allegheny and Yale, Allegheny and McCormick, and Cape and Yale were calculated. These are plotted in Figures 1b, 2b, and 3b. Comparing Figures 1a and 1b we find that they correlate suggestively.

Although the comparison of Figs. 1a and 1b is suggestive, similar but small parallax differences in the (A-M) and (C-Y) data exist even when the temperature range variations are in phase and therefore nearly cancel (Figs 2b and 3b). This is perhaps not too surprising since we are dealing with four different telescopes whose objectives may react in different ways to thermal gradients or to different temperatures.

IV. DISCUSSION

There is some evidence, then, for a systematic annual error in trigonometric parallax determinations resulting from the annual temperature cycle. It is more difficult to establish the mechanism by which this error enters. Some nonlinear effect must be at fault, else the error would have been removed during the linear dependencies reduction of the measurements. Atkinson (1971) has proposed a possible culprit: temperature dependent decentering of the components of the telescope objective. Conrady (1919) has studied the aberrations expected from such decentering, finding that extra-axial points shift with respect to field center in a nonlinear way.

While this mechanism is plausible, it cannot be established by the present results. The actual detection of decentering aberrations must await experimentation such as that advocated by Atkinson. However, other consequences of decentering can be looked for in the parallaxes. Davidson (1934) has pointed out that inconstant decentering might introduce a systematic error depending upon color. Figure 4 illustrates the differences in the relative parallaxes,

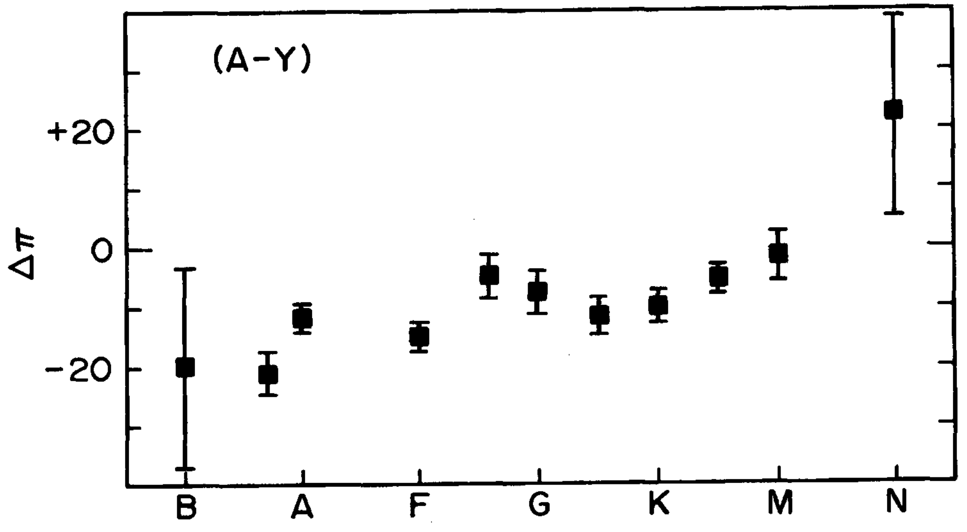

Figure 4. The (A-Y) parallax differences in units of 0.001 arc-sec as a function of the spectral type.

Allegheny minus Yale, as a function of the spectral type of the parallax star. Despite considerable scatter a trend is evident, the mean difference for M stars being about 0".01 greater than for A0 stars. Again, it is possible, but by no means certain, that this results from temperature dependent decentering.

In a recent investigation, Kamper (in preparation) finds a systematic difference in the astrometric data obtained with the Yale refractor between its Johannesburg and Mt. Stromlo locations. He notes that there is reason to believe that the refractor was misaligned during part of the time while it was at Johannesburg thereby producing color dependent shifts in stellar positions. Turon LaCarrieu and Creze (1976) also comment that they feel that the southern parallaxes are systematically in error.

There is thus a case for re-examining the systematic differences between parallaxes from different observatories in greater detail. Though Gliese (1972) has suggested that the Allegheny system may on the whole be free from substantial systematic errors, this result needs confirmation. Since the errors may vary with right ascension it is possible that certain parts of the sky may be subject to systematic effects much larger than that of the entire Allegheny system. There can be little complacency until it is reliably established that these systematic errors do not translate into significant errors in the luminosities and masses of stars.

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