THE YALE PARALLAX CATALOGUE

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ABSTRACT: A new edition of the General Catalogue of Trigonometric Stellar Parallaxes is being prepared at the Yale University Observatory. The Catalogue will include all published photographic parallaxes, a reference to the source of the published parallax, UBV photoelectric photometry, MK spectral types, cross identifications with other catalogues, data on the binary nature of the stars and auxiliary information to aid in determining the reliability of the data. An analysis of the parallaxes corrected to absolute has been made to study the accidental and systematic errors of the parallaxes. The new edition will be available in both printed and magnetic tape versions.

1. INTRODUCTION

The last edition of the Yale General Catalogue of Trigonometric Stellar Parallaxes (YPC) was published by Jenkins in 1952, followed by a Supplement in 1963. Since that time, new astrometric telescopes have been built and the methods of measurement and reduction have changed substantially. In addition, it has been known for many years that the corrections applied to the individual parallaxes in the previous edition of the YPC are probably not valid. Given these changes and problems, and the addition of numerous high accuracy parallaxes, it was felt that a new edition of the YPC should be compiled.

In order to make the new edition of the YPC as useful as possible, it was decided to include UBV photoelectric photometry and MK spectral types for all of the stars for which that data was available. In addition, we went back to the literature and created our own data base of all photographically determined parallaxes, including a variety of information that might prove useful in evaluating the presence of systematic errors. Among the data included in the data base are: the source of publication for each parallax; the average magnitude of the reference stars; and the reduced magnitude of the parallax star. All of these data will appear in the version to be published.

As of this time, the working version of the YPC contains 14336 parallaxes for 7607 stars. Of these 14336 parallaxes, 1033 have been superseded by subsequent measurements and 586 are negative. When the multiple observations are combined, the resulting distribution of parallaxes

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shows that approximately half of the stars have parallaxes that are smaller than their standard errors. It is obvious therefore that considerable care must be exercised in the selection of stars for the calibration of luminosities and that the extent and nature of the systematic errors in the parallaxes must be known if the reliability of the resulting calibration is to be judged. In the following sections, we will outline the methods used to study the errors of the parallaxes and highlight the results of these investigations. The details of our analyses will be published in a later paper.

2. ANALYSIS

Two methods have been used to evaluate the errors of the parallaxes. Hertzsprung (1952) showed that the distribution of negative parallaxes could be used to determine their average error, and Hanson (1980) expanded the method to include the distribution of all parallaxes, positive and negative; we will refer to this approach as the Hertzsprung method. The second method used is to compare the parallaxes determined for the same star at different observatories. This is the classical approach used by Jenkins (1952) to determine the systematic and external errors of the parallaxes; we will refer to this as the Observatory Pairs method.

The Hertzsprung method relies on the fact that parallax observers generally select stars to observe that they expect to have measurable parallaxes. The result of this selection is that the sample of stars will have a more or less well defined true distance limit. If the stars are uniformly distributed in space, then most of the stars will lie near the true parallax limit. In contrast, their measured parallaxes (distances) will scatter to both the positive and negative side of the true parallax. As a consequence, stars with true parallaxes close to zero will sometimes be scattered into the negative measured parallax region. An analysis of the distribution of negative parallaxes should then yield the average error of the parallaxes.

In practice, there are several problems with the interpretation of the errors derived from the Hertzsprung method. First, parallax observers tend to take more care with the interesting stars that have larger and therefore more useful parallaxes. As a result, the smallest measured parallaxes will, in general, have the largest errors and not be representative of the sample as a whole. Second, in the past some observers have been known to selectively not publish negative parallaxes, since they are not "real", or to continue with the observations or reductions until the parallaxes are "positive". These procedures will bias the derived errors to smaller values than are representative of the entire set of data from the observatory in question. Finally, the distribution of true parallaxes may not be that of a uniform distribution in space due to the observational selection effects and that will bias the derived error. Hanson (1980) studied this problem and developed a method to allow for the determination of the true distribution and the average error simultaneously. However this powerful method does not solve the two problems mentioned before.

The Observatory Pairs method compares the individual parallax differences for stars measured by several observatories; for example, the Cape and Yale parallaxes for all stars in the YPC. Plotting these data in a probability plot (see Lutz (1978)) and solving for the slope and zero-point of

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the data then yields robust estimates for the accidental error of the parallax differences and the systematic difference between the observatories. This procedure is then used to estimate the errors and differences between all observatory pairs. Finally, a least-squares solution including all combinations of the variances yields the external errors of the individual observatories. Similarly, another solution for the average zero-points will yield the systematic difference of each observatory from the defined system zero. In the later case, it is necessary to define one observatory as the zero-point for a mathematical constraint. The choice is purely arbitrary here since we have chosen not to apply systematic corrections to the parallaxes for reasons that will be discussed later.

In all of the above comparisons we have first corrected the individual relative parallaxes to absolute using the tables given by van Altena (1974). It is important to make the correction first, since in most cases the average reference frame magnitude varies considerably between the difference observatories, even for observations of the same star. Similarly, the average reference frame magnitude varies for one observatory, often by several magnitudes. This makes it important to correct each observation rather than the observatory as a whole, as was done in the earlier version of the YPC.

3. RESULTS

Since the observational programs and techniques at some observatories have changed significantly with time we have treated the individual segments separately. We have compared the solutions for the external error of each observatory as determined from the Hertzsprung and Observatory Pairs methods. Not surprisingly, there is in general very little correlation between the error derived from the two methods. This is probably due to the limitations of the Hertzsprung method, so we have not used those data to estimate the external errors of the parallaxes.

Following Jenkins (1952), we have broken the data samples down further into those cases where there were more than 40 plates in a parallax series and another sample where there were fewer than 40 plates. A comparison between the external error calculated here by the Observatory Pair method and that published by the Observatory, shows excellent agreement for almost all observatories. In fact, the data indicate that the errors published by the observatories for series with more than 40 plates are equal to their external errors. For the sample with fewer than 40 plates, we find that the published errors are about 15% smaller than the external errors as calculated by the Observatory Pairs method. Based on these comparisons, we have adopted the following precepts for calculating the external errors of the new edition of the YPC. For parallax series with fewer than 40 plates, the published error (converted to a standard error) is increased by 15%; in those cases where there are more than 40 plates the error as published is adopted. This pragmatic approach is certainly not perfect, but given the heterogeneous nature of the data sample, it should be adequate.

The more difficult problem to solve is that of the systematic corrections to the observatory zero points. It is relatively simple to imagine how an observer can underestimate the error of a parallax, for example by rejecting discordant data points. However, it is much more difficult to propose a

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reasonable scheme that would shift all of the parallaxes to larger or smaller values. A possible source for such a shift might be that the exposures are generally taken with a lens that is warmer in the evening than it is in the morning. This thermal difference might introduce a shift, but that has not been demonstrated.

We have computed the mean differences of the parallaxes for each observatory and find few surprises. In a presentation of our first examination of this problem, van Altena (1986) showed in his Fig. 1, a plot of the differences with the magnitude of the parallax star. The most obvious feature of that diagram was the apparent deviation of the Allegheny bright stars from the mean of the other observatories. This magnitude equation had been noticed earlier by Hanson (1978) and a correction to the Allegheny parallaxes as a function of magnitude was proposed by Lutz *et. al.* (1981). Since that time we have extended the data sample and find that the correction is about one-half that proposed by Lutz *et. al.* Other features in the new difference plot are the well known deviation of the Yale southern parallaxes from the Cape. In this case, since only the Cape and Yale contributed significant data samples to the YPC in the southern hemisphere, a plot of the differences versus magnitude for either observatory tends to mirror a similar plot for the other. Finally, there is a hint that the Naval Observatory parallaxes are systematically smaller than those measured elsewhere. These data are being reexamined before the final system of the YPC is established. In any case, it is likely that the only corrections that will be applied to the published parallaxes, aside from the correction to absolute, are the well known magnitude correction for the Dearborn parallaxes and possibly some fraction of the magnitude correction for the Allegheny parallaxes proposed by Lutz *et. al.* (1981).

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Discussion:

MURRAY You say rightly that the suppression of negative parallaxes vitiates the Hertzsprung test. Surely it also affects the dispersion extracted from the probability tests?

VAN ALTENA There will probably be a small effect, but I have not evaluated its importance.

GLIESE 1) Do you give in the published version of the GCTSP the assigned classes: Good, Fair, Poor and do you have strong rules for defining these classes of accuracy?

2) Lutz-Kelker corrections should be applied to observed series of parallaxes used statistically for calibration purposes, not for individual stars.

VAN ALTENA 1) The quality classification of Good, Fair, Poor refers to the dispersion (internal) of parallaxes for a star. If the ratio of the dispersion to the formal error, Q = dispersion/standard error < 1.5 we call the parallax G; for $1.5 < R < 2.5$, Q = F; and for $R > 2.5$, Q = P. This arbitrary choice may be changed in the published version.

2) No Lutz-Kelker corrections have been applied to any of the parallax catalogue data. They should, however, be used as a statistical correction when calibrating luminosities.

CORBIN Will any special effort be given to obtaining parallaxes of FK5 extension stars, such are needed for foreshortening terms and apparent places?

VAN ALTENA Not that I know of unless the USNO has such plans.

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