THE SYSTEM AND QUALITY OF THE AGK3U

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1. Introduction

The methods used to assess the quality and the system of the AGK3U (Bucciarelli et al. 1992) are reviewed. However, the point of this paper is that **all** star catalogs should undergo a comparable evaluation. It is too easy to follow the recipes of statistics, examine internal measures, declare success, and move on. All recipes can be ruined with the wrong ingredients and the theorems of statistics are no different. Since it is impossible to verify that the hypotheses are a priori fulfilled, one has to be resourceful and devise methods which fully test the outcome a posteriori. The AGK3U has been so examined; our efforts are described herein. (The AGK3U is the first attempt to combine astrometrically reduced Schmidt plate positions with those from astrographic plates [Taff 1989; Taff et al. 1990]. Our sub-plate code will be available soon because of NASA support to make it portable.)

2. Schmidt Plate Positions

Of especial importance to this Symposium, the difficulty in astrometric Schmidt plate reduction is the elimination of systematic errors. No polynomial model can remove the effects of bending the plate to conform to the spherical Schmidt focal surface. (See Fig. 3 of Bucciarelli et al. 1992). We invented sub-plates (Taff 1989) to deal with this. We used an objective process to evaluate the sub-plate technique; namely the ~ 53 CAMC stars/plate on the 764 northern hemisphere 'Quick-V' plates were re-reduced for the AGK3U. The CAMC positions played no role in the original reduction, hence the weighting of the new positions was independent. This type of autonomous double-check can be performed for any star catalog.

3. Least Squares Fitting and Mean Errors

We combined our new coordinates with those from the AGK2 and 3 and utilized least squares to fit them; i.e. we wrote the usual linear temporal models for the RA and DEC and then we (separately) minimized the sum of the squares of the respective residuals. Next, as is standard,

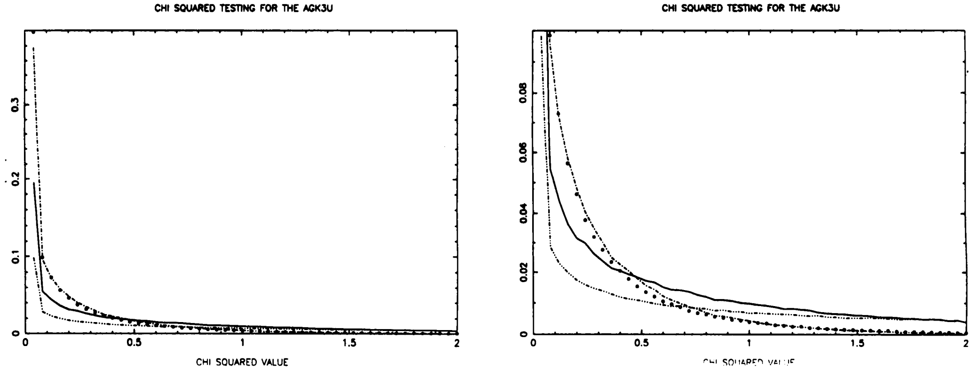
H. T. MacGillivray et al. (eds.), Astronomy from Wide-Field Imaging, 271–275.

we used the sample variances to obtain estimates for the mean errors of the new positions and angular velocities. Are these estimates any good? Do they really describe the quality of the new coordinates or proper motions? How can one tell? These questions are addressed below; meanwhile there is a different query we can pose, namely "Do the residuals in RA or DEC after the fits have the predicted properties?" By this we mean, "Does the distribution of residuals follow the chi-squared distribution with N - 2 degrees of freedom?"

We have ~ 200,000 values to build an empirical image of the residuals' distribution function (Fig. 1). Since N is usually 3 for an AGK3U star, and the chi-squared distribution for one degree of freedom has a singularity, we modelled the distributions by Monte Carlo simulation. (This also more closely approximates the origin of our curve). In addition, we performed the numerical experiment twice more: once with the nominal errors halved and once with them doubled. Figure 1a shows that the residuals are essentially chi-squared distributed with one degree of freedom, including the singularity at the origin. However, as the enlargement in Fig. 1b shows, the fit to the doubled error curve is much better than to the ostensible weight curve. The implication is that we have the incorrect assignment of weights — despite the fact that the mean errors were empirically determined by external methods.

4. Direct Coordinate and Proper Motion Mean Error Checking

The simplest comparison to make is between independently produced catalogs. The AGK3U has a 626 star overlap with the FK5 Extension. The average equatorial coordinate differences were 0"018 ± 0"193 for RA on a great circle and -0"018 ± 0"198 for the DEC (at B1950.0; the FK5



a. **b**

Figure 1. a) AGK3U (solid) and Monte-Carlo simulation residual distributions. The dot-dash curve assumed that the errors were twice as large as estimated; for the other curve the assumption was that the errors were half the nominal value. **b)** Enlargement of Fig. 1a. Note the good agreement to the wrong curve.

EXT was first put on the system of the FK4; see Lattanzi & Taff 1993). The mean errors are about twice the AGK3U value. This is because the FK5 EXT stars are the brightest in the AGK3U coupled with a steep dependence on magnitude in the Schmidt plate reductions; see Fig. 2.

For the proper motions, the differences were -0''.025/cy ± 0''.604/cy and 0''.082/cy ± 0''.669/cy respectively. The standard deviations are very close to the AGK3U value of 0''.58/cy. Thus, we conclude that the system of the AGK3U is that of the FK4 and that the error estimates given in the AGK3U are substantially correct. Once again we make the point of using a catalog with no correlation with the one under study to externally judge the formally computed mean errors.

5. Indirect Coordinate and Proper Motion Mean Error Checking

Bucciarelli et al. (1993) describe the results of an inter-comparison among the FK3/4/5 based on a new method. A by-product was an examination of their systematics. The FK catalogs failed to agree with the predictions of the Central Limit theorem whereas the GC and N30 did (Taff & Bucciarelli 1993). The FK3/4/5 shortcoming is simplest to see in the distributions of the normalized coordinate differences; we showed that, contrary to theory, they are non-Gaussian. Figure 3 shows the AGK3U comparison with the FK5 EXT. We conclude that both the AGK3U mean errors are correct, that its system is that of the FK4, and very smooth. The chi-squared goodness-of-fit values were 26 and 88 for the RA and DEC respectively (vs. the theoretical expectation of 25 ± 7), cf. Lattanzi & Taff (1993).

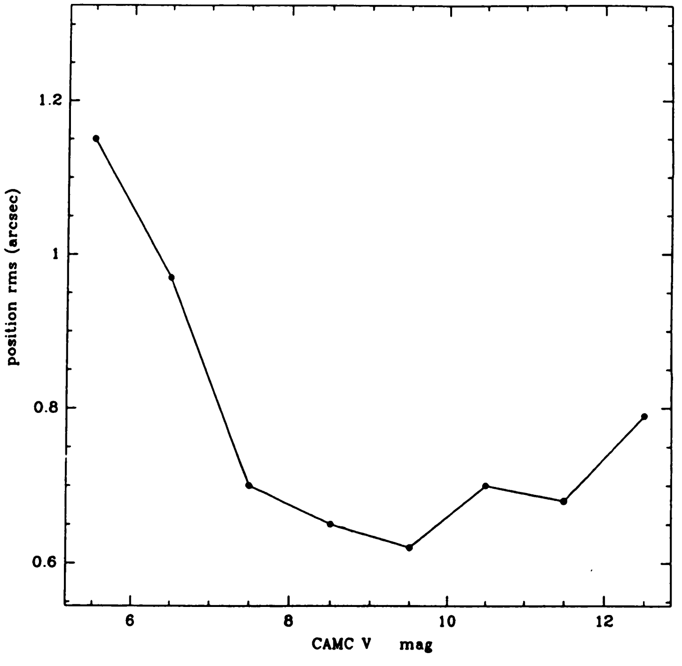


Figure 2. V magnitude dependence of 'Quick-V' Schmidt plate positional errors for CAMC stars.

https://doi.org/10.1017/S0074180900047446 Published online by Cambridge University Press

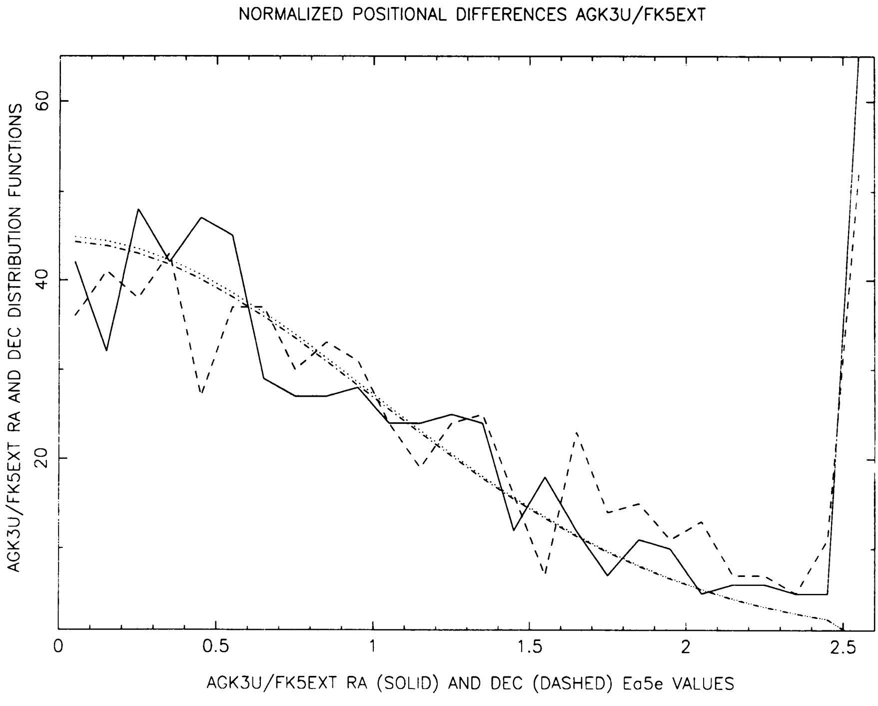


Figure 3. Normalized coordinate difference curves for the AGK3U/FK5 EXT. The solid curve is for the RA, the dashed for the DEC, and the two smooth curves are from the theory (minus the outliers which are beyond 2.5).

6. Galactic Kinematics and Common Proper Motion Stars

Another type of error is one wherein the proper motions depend on the color index. An indirect strategy to search for this effect is to perform a galactic kinematics analysis. Our results have been briefly described in the Wide-field Imaging Group Newsletter 3 and are being prepared for publication (Lattanzi et al. 1993). In particular, whereas the AGK3U has no such problem, the ACRS Part 1 does.

An application of star catalogs is to search for common proper pairs. However, if this is carried to an extreme — to a level of probability approaching 100% — then it can be used to evaluate the catalog's average proper motion error. We discovered this by accident when we made a coding error (see the aforementioned Newsletter article). We showed that the ACRS Part 1, the AGK3, and the AGK3U average proper motion errors were correct but that the PPM North estimate was a factor of ~1.6 too low (see also Molotaj et al. 1992).

Acknowledgements

This was work supported in full by NASA Grants NAGW-2597 and one to make the sub-plate code portable.

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