An Astrometric Comparison Between Glass and Film Negatives on the UKST

1. Introduction

The intention behind this comparison is to see if there is any astrometric difference between using film or glass as the primary recording medium in the UK Schmidt Telescope (UKST).

The main comparison was carried out in UKST field number 386 using plates OR14216 (glass) and OR14387 (film). This field has Galactic coordinates $(l,b) = (330°, 20°)$ and is thus in an area with a very high star density. The difference in epoch between these plates is about 3.5 months.

The 'control' field that was used was the 8 Hour Field used in Evans (1988). The plate material used was J6644 and J6814 (both glass originals). This field has Galactic coordinates $(l,b) = (210°, 35°)$. The difference in epoch in this case is about 3 months.

2. The Data Reductions

All plates were scanned by the APM (in both 0° and 180° orientations) and various reduction procedures were applied to the data in order to remove any systematic effects present in the data caused by either the process of producing the plates or the scanning. These procedures are described in detail in Evans (1988).

The main systematic effect is caused by differential atmospheric refraction (see Wallace & Tritton, 1979) and distortion of the plates. These errors are accounted for by applying a map of these distortions to the data, i.e. making the assumption that no **average** shift in the positions as a function of the plate position can be a result of an astronomical effect. Note that by using galaxies as an absolute reference frame the global proper motion, and its gradient across the plate, is reinstated.

For the plates OR14216 and OR14387 the zenith angle is quite small (~ 9°) and hence the size of the differential atmospheric refraction will be small. Thus any remaining effect will be due to distortions caused by the plates. Figure 1 shows the map used between the 0° scans of OR14216 and OR14387. The larger distortions are of order an arc second. Of course, these distortions could be present in either the glass or the film plate. It is also possible that a small amount of these errors are caused by the scanning.

3. The Comparison

An important point about the selection of the plates used in these comparisons is that the epoch difference between the plates should be small. This is to minimize the effect of proper motions on the distributions. An estimate of the size of the effect for the 8 Hour Field plates (the control) is an additional dispersion of about 0.002 arcseconds. If added in quadrature to the measured widths it can be seen to be negligible.

Due to the crowded nature of the field a larger number than normal of mismatches occur. This leads to a number of outliers being present in the distributions of the positional comparison. Because of this, 4 different sorts of width estimator for the distributions were used:

(1) Gaussian fit to the histograms of the distribution;
(2) Interquartile estimator (scaled to a Gaussian width);
(3) Standard deviation;
(4) Standard deviation with an a priori cut of 1 arcsecond.

Probably (1) is the best estimator to use in order to measure the width of the core of the distribution and not be affected by the outliers. This is what was used in the following results.

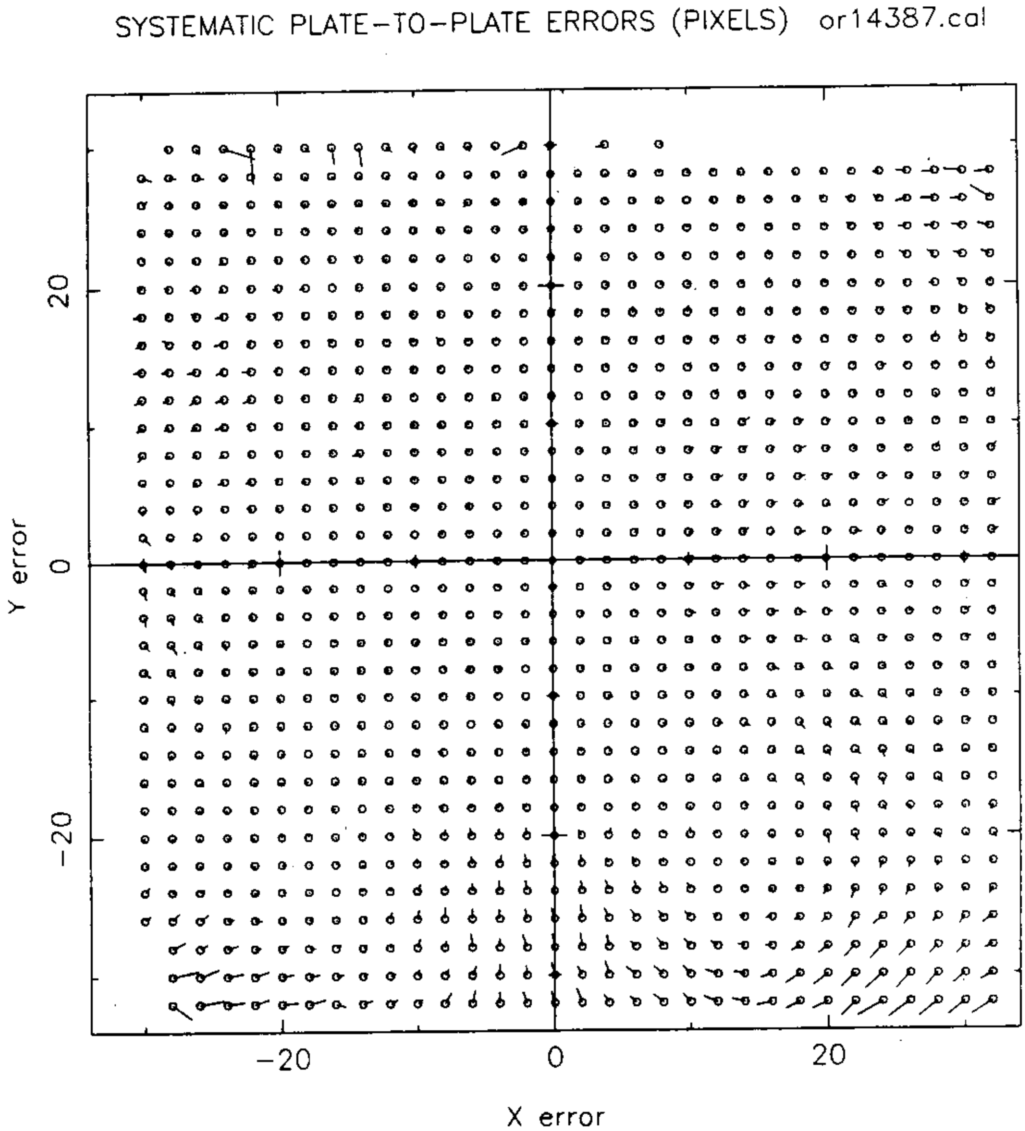

Figure 1. This diagram shows the size of the systematic effects present between the 0° scans of OR14216 and OR14387. The position of the circles represent positions on the plates. The whole plot roughly represents a UK Schmidt plate (about 6° x 6°). The average error at a particular position is indicated by the length of the line starting at each circle. The scale for these lines correspond to those of the axes, which is in scanning machine pixels. A pixel is approximately 0.5 arcsecond. It should be noted that in producing these plots a linear six plate constant transformation has already been applied to the data.

The basic comparison was carried out using the averaged (of the 0° and 180° scans) positions from the glass and film plates. The widths of the distributions were

	x	*y*
Glass vs. Film (av.)	0.086″	0.084″

x and *y* correspond roughly to the axes of right ascension and declination.

If you compare the 0° and 180° scans of the glass plate OR14216 you obtain widths of

	x	*y*
Glass 0° vs. 180°	0.050″	0.063″

This will be $\sqrt{2}$ times the error due to scanning, which is of order 0.5 μ per plate measure.

For an averaged difference distribution the width will be given by

$$\sigma=\sqrt{2\sigma_p^2+\sigma_s^2}$$

where σ_p is the error due to the plate and σ_s is that due to the scanning. This is assuming that plate errors and all the scanning errors add quadratically i.e. they are independent random errors. The reason we treat the plate and scanning errors differently is that there are 4 scans which contribute to the difference distribution and are averaged while the plate errors are not really combined 4 times since there are only 2 different plates. (Note that if you don't average the distributions over the 0° and 180° scans the width is given by $\sigma=\sqrt{2\sigma_p^2+2\sigma_s^2}$.)

Therefore the average (assuming glass and film to be the same) individual plate error is

	x	y
Plate error	0.055″	0.050″

This corresponds to around 0.75 μ.

As a check on these values it can be seen if a similar result can be obtained by comparing just the 0° scans, i.e. the distributions are not averaged. These measurements yield

	x	y
Plate error (from only 0° scans)	0.060″	0.056″

As a control, scans of two glass plates (J6644 and J6814) from the 8 Hour Field of Evans (1988) were compared. The width of the distribution of the differences between the averaged positions on these two plates was

	x	y
Glass vs. Glass (av., 8 Hour)	0.085″	0.094″

In order to obtain σ_s for these scans the 0° and 180° scans for one of the plates were compared. These yielded widths (= $\sqrt{2}\sigma_s$) of

	x	y
Glass 0° vs. 180° (8 Hour)	0.042″	0.067″

Thus we can calculate the plate errors for just glass plates:

	x	y
Plate error (8 Hour)	0.056″	0.057″

4. Conclusions

From the plates that have been scanned and analyzed for this work the conclusion is that there is not much difference (if any) between the astrometric results from film and glass plates.

It must be stressed that this is very much a **preliminary** result. No formal error estimates have been given for the values of the widths of the distributions since it is unclear that a formal error analysis would be appropriate or useful. An **estimate** of the error would be ~ 10%. This comes from comparing the x and y plate errors and comparing the averaged with the 0° results. Since film is only part of the plate pair combination we can probably say that a film is within ~ 20% of the accuracy of glass.

Naturally, the way to progress from here is to analyze more films and see how the results differ. In particular, since we have already characterised both the systematic and random errors present for glass vs. glass comparisons the next step is to do film vs. film comparisons on the same field. After all, the finer grain size of the film should lead to improved astrometric results at least for the random component of error. Theoretically a factor of 2 improvement is possible.

Acknowledgements

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References

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