

# LOCAL SYSTEMATIC DIFFERENCES IN 2MASS POSITIONS

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## RESUMEN

Se ha encontrado que las posiciones en el catálogo 2MASS de fuentes puntuales muestran diferencias sistemáticas locales en escalas de  $\sim 5$  a  $\sim 8$  minutos de arco cuando se comparan con otros catálogos. Se observa que cuando las posiciones 2MASS son empleadas en el cálculo de movimientos propios, dichas diferencias sistemáticas causan errores sistemáticos en los movimientos propios resultantes. Se ha desarrollado un método para rectificar localmente 2MASS con respecto a UCAC4 con el fin de reducir las diferencias sistemáticas entre estos catálogos. El catálogo 2MASS rectificado con el método propuesto puede considerarse como una extensión de UCAC4 para la astrometría con precisión de alrededor de 90mas en sus posiciones, con errores sistemáticos despreciables. También se muestra que el uso de estas posiciones rectificadas eliminan el patrón sistemático observado en movimientos propios derivados de las posiciones 2MASS.

## ABSTRACT

We have found that positions in the 2MASS All-sky Catalog of Point Sources show local systematic differences with characteristic length-scales of  $\sim 5$  to  $\sim 8$  arcminutes when compared with several catalogs. We have observed that when 2MASS positions are used in the computation of proper motions, the mentioned systematic differences cause systematic errors in the resulting proper motions. We have developed a method to locally rectify 2MASS with respect to UCAC4 in order to diminish the systematic differences between these catalogs. The rectified 2MASS catalog with the proposed method can be regarded as an extension of UCAC4 for astrometry with accuracy  $\sim 90mas$  in its positions, with negligible systematic errors. Also we show that the use of these rectified positions removes the observed systematic pattern in proper motions derived from original 2MASS positions.

*Key Words:* astrometry — catalogs — proper motions — methods: data analysis — methods: miscellaneous

## 1. INTRODUCTION

This contribution is based on results presented in Bustos Fierro & Calderón (2016a,b). This work was motivated by the systematic errors found in positions derived from deep CCD images reduced using 2MASS (Skrutskie et al. 2006) as reference catalog. When position differences between 2MASS and other catalogs such as UCAC4 (Zacharias et al. 2013), SPM4 (Girard et al. 2011) and SDSS-DR9 (Ahn et al. 2012) were computed, the same patterns of systematic differences were found. When we compared the proper motions in catalogs derived from 2MASS positions -namely PPMXL (Roeser et al. 2010) and URAT1 (Zacharias et al. 2015)- with proper motions independent of 2MASS -namely UCAC4, SPM4 and USNO-B1 (Monet et al. 2003)- we found systematic differences with features similar to the patterns recently described.

## 2. RECTIFICATION OF POSITIONS AND IMPROVEMENT IN PROPER MOTIONS

In Bustos Fierro & Calderón (2016a), we proposed a method to locally rectify 2MASS with respect to UCAC4, on  $3^\circ \times 3^\circ$  fields on the sky where we defined a square grid of step  $\rho$ , aligned with RA and DEC. On each node of the grid  $(\alpha_g, \delta_g)$  we calculated the weighted mean difference  $(\alpha_{2MASS} - \alpha_{UCAC4}, \delta_{2MASS} - \delta_{UCAC4})$  inside a *smoothing area* centered in that node, as a measure of the mean systematic differences between 2MASS and UCAC4 in that node.

In order to perform the rectification, for each position  $(\alpha_{2MASS}, \delta_{2MASS})$  we computed the correction  $(\Delta\alpha, \Delta\delta)$  by means of a two-dimensional cubic spline interpolation of the mean differences in the nodes of the grid. Corrected coordinates  $(\alpha_{2MASS-R}, \delta_{2MASS-R}) = (\alpha_{2MASS} - \Delta\alpha, \delta_{2MASS} - \Delta\delta)$  were computed. Figure 1 shows the differences in RA between 2MASS and UCAC4 before and after the rectification in one analyzed field.

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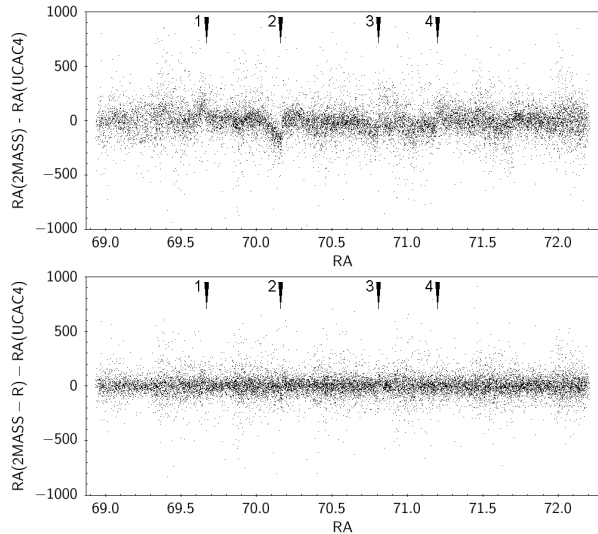


Fig. 1. RA differences 2MASS–UCAC4 in mas. (a) Before rectification. (b) After rectification. The arrows numbered 1 through 4 point to some characteristic features of the systematics that are easily recognised.

### 3. PROPER MOTIONS DERIVED FROM RECTIFIED 2MASS POSITIONS

We then calculated proper motions in one of the fields, using first epoch positions from the rectified 2MASS and second epoch positions from URAT1. We call these proper motions  $\mu_\alpha(2\text{MrUR1})$ ,  $\mu_\delta(2\text{MrUR1})$  and they are defined in the usual way. We computed the differences between these the proper motions and the ones in UCAC4 and USNO-B1. The differences with UCAC4 are shown in Figure 2, where it can be seen that the systematic differences were greatly reduced.

### 4. CONCLUSIONS

The proposed method was able to reduce the systematic differences between 2MASS and UCAC4 well below random differences in all the fields analysed in this work. After rectification, the mean differences 2MASS–UCAC4 are null, and the rms differences are reduced from  $\sim 140$  mas to  $\sim 90$  mas. Our 2MASS rectified catalog can be regarded as an extension down to  $K_s = 15$  of UCAC4 for astrometry, with accuracy around  $\sim 90$  mas in its positions.

We have proved that the proper motions of PP-MXL and URAT1 are strongly affected by the systematic differences in positions observed in 2MASS, especially URAT1. We have also shown that using our *rectified* 2MASS as first epoch and URAT1 as second epoch for the determination of proper motions, in a similar way to the determination in URAT1, the systematic effects become negligible.

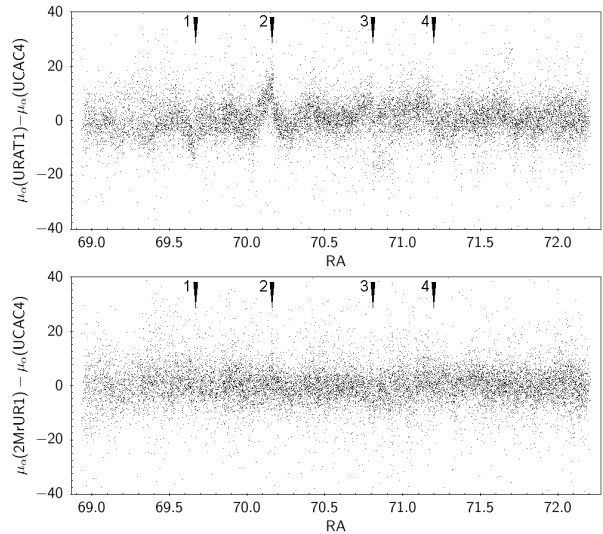


Fig. 2. (a)  $\mu_\alpha$  difference URAT1–UCAC4 in mas/yr. (b)  $\mu_\alpha$  difference 2MrUR1–UCAC4 in mas/yr. The positions of the arrows are the same as in Figure 1.

### 5. ACKNOWLEDGMENTS

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### REFERENCES

- Ahn, C. P., Alexandroff, R., Allende Prieto, C., et al. 2012, ApJS, 203, 21
- Bustos Fierro, I. H., & Calderón, J. H. 2016a, Revista Mexicana de Astronomía y Astrofísica, 52, 143
- Bustos Fierro, I. H., & Calderón, J. H. 2016b, Revista Mexicana de Astronomía y Astrofísica, 52, 413
- Girard, T. M., van Altena, W. F., Zacharias, N., et al. 2011, AJ, 142, 15
- Monet, D., Levine, S., Canzian, B., et al. 2003, AJ, 125, 984
- Roeser, S., Demleitner, M., & Schilbach, E. 2010, AJ, 139, 2440
- Skrutskie, M. F., Cutri, R. M., Stiening, R., et al. 2006, AJ, 131, 1163
- Zacharias, N., Finch, C. T., Girard, T. M., et al. 2013, AJ, 145:44
- Zacharias, N., Finch, C., Subasavage, J., et al. 2015, AJ, 150:101