University College Dublin

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PHYC20040 Exploring the Solar System

Experiment No.4 Astrometry of Asteroids

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Contents

Abstract

1 Theory

1.1 Introduction to Astrometry

Astrometry is a type of astronomical measurement technique that focuses specifically on measuring the location of moving celestial objects within the sky plane [1]. This was one of the first techniques developed for searching planets around other stars, and remains a fundamental tool to astronomers to this day [2, 1].

There are, of course, standard errors that come from measuring the movement of celestial objects through astrometric observations. This applies to both one's personal measurements and those found in star catalogues. There will always be noise error when collecting photons from the targets, whether that be from background noise or from the target itself, photon distribution will vary between measurements at each different exposure time [3]. When measuring the position of an asteroid there will be tracking errors due to the fact that astroids move, sometimes producing trails that are neither straight nor uniformly illuminated, hence determining the centre is difficult [3]. These are examples of random errors that can be encountered, but there also exist systematic errors. The reference star catalogue may have possible zone errors, meaning stars have a bias for a particular region of the sky that apply to any other asteroid measured in that sky region. The Hipparcos mission (1989-1993) was able to better pinpoint star's motion and position, thus effectively lessening this error [3] and is being further refined by the Gaia mission (2013-2025) [4, 5].

1.2 Equatorial Coordinates

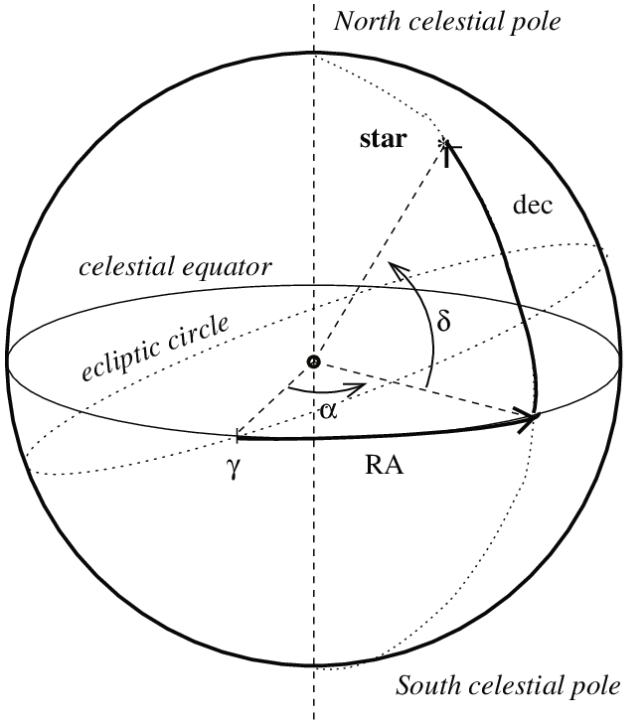

Figure 1: Definition of equatorial coordinates system on the sky. Observer is at the centre of the sphere, which has an arbitrary radius of ∞ [6].

1.2.1 Right Ascension and Declination

1.2.2 Reference Star Catalogues

FK5 [7].

Hubble Space Telescope Guide Star Catalogue (HST GSC) [8].

1.3 Celestial Coordinates

1.4 Principles of Parallax

2 Methodology

3 Results and Discussion

4 Conclusion

References

[1] M. Endl and W. D. Cochran, "CHAPTER 47 - Extrasolar Planets," in *Encyclopedia of the Solar System (Second Edition)*, 2nd ed., L.-A. McFadden, P. R. Weissman, and T. V. Johnson, Eds. San Diego: Academic Press, 2007, pp. 887–902. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B9780120885893500517

[2] CLEA, *Astrometry of Asteroids*, November 2008.

[3] W. M. Owen Jr, "Error Sources in Asteroid Astrometry," *NASA*, 2000.

[4] ESA. (1989-1993) Hipparcos overview. [Accessed 22 March 2025]. [Online]. Available: https://www.esa.int/Science_Exploration/Space_Science/Hipparcos_overview

[5] ——. (2013-2025) gaia mission. [Accessed 22 March 2025]. [Online]. Available: https://www.esa.int/Science_Exploration/Space_Science/Gaia

[6] J. Patris, "Preparing astronomical observations and observing with OHP facilities," *EPJ Web of Conferences*, vol. 9, p. 217, December 2010.

[7] W. H. Warren Jr, "Fifth Fundamental Catalogue (FK5). Part 1: Basic fundamental stars (Fricke, Schwan, and Lederle 1988): Documentation for the machine-readable version," *NSSDC WDC-A-R&S*, 1990.

[8] NASA. (2012, August) GSC - HST Guide Star Catalog, Version 1.2. [Accessed 22 March 2025]. [Online]. Available: https://heasarc.gsfc.nasa.gov/w3browse/all/gsc.html

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