RevMexAA (Serie de Conferencias), **46**, 72–73 (2015)

THE NEW GENERATION OF ASTROMETRISTS

William F. van Altena[1], read by René A. Méndez[2]

RESUMEN

El conjunto de conocimientos y habilidades que requiere la nueva generación de astrómetras se ha incrementado dramáticamente en tiempos recientes, debido a los aceleradas mejoras en precisión y certidumbre en las mediciones producto de los avances tecnológicos. Lograr certidumbres de microsegundos de arco había sido posible hasta ahora sólo con radio-interferometría pero pronto con el satélite GAIA de la ESA, tal nivel de certidumbre será alcanzable también en la parte óptica del espectro. Las habilidades que se requieren para ello han formado parte del sistema educativo en el área radio-astronómica, pero debido al retraso de la tecnología en el óptico éstas no han sido incluidas en la mayoría de los cursos de astrometría óptica. Para rectificar esta deficiencia yo he reunido a un grupo de especialistas en las áreas requeridas y juntos escribimos un nuevo libro texto introductorio en astrometría, cuyo objetivo es educar a estudiantes e investigadores en los métodos requeridos para la recolección, reducción y análisis de posiciones, paralajes y movimientos propios del orden de microsegundos de arco.

ABSTRACT

The knowledge and skill sets required for the next generation of astrometrists have increased dramatically from that needed in the past primarily due to the rapid increases in measurement precision and accuracy enabled by technological advances. The era of micro-arcsecond accuracy was launched by radio interferometry and ESA's Gaia satellite will soon provide that level of accuracy in the optical part of the spectrum. Some of the skills required have been a part of the education system in the radio-astronomical area but due to the lagging of technology in the optical part of the spectrum they have not been included in most optical astrometry courses. To rectify this deficiency I organized a group of specialists in the required areas and together we wrote a new introductory textbook on astrometry whose goal is to educate students and researchers in the methods required to deal with collection, reduction and analysis of micro-arcsecond positions, parallaxes and proper motions.

Key Words: astrometry — astronomical databases

1. INTRODUCTION

The next generation of astrometrists will need to prepare themselves for new technologies and analysis techniques and how best to apply them to both ground and space observations. While the absence of a disturbing atmosphere enables the collection of high precision and accuracy data, the most obvious limitations imposed on space instrumentation are the limited aperture size and the relatively short time domain that it samples. Mission lifetimes are generally planned for a few years, however NASA's Hubble Space Telescope, which was launched in 1990 has turned into a very extended and extraordinarily productive scientific mission that is still producing valuable high precision data a quarter of a century later. Other projects have had shorter lifetimes such as ESA's pioneering Hipparcos satellite whose data collection mission lasted from 1989 to 1993 and Gaia, which was launched in late 2013 and is planned to last for five years.

Ground based telescopes on the other hand, collect data whose positional integrity is limited by the disturbing effects of the atmosphere, generally have lifetimes of many decades and are able to probe much deeper into space due to the immense sizes of the apertures that are now being produced. The different time domains applicable to space and ground based observations usually mean that the types of astrometric science that they are most suited to exploit are rather different. For example, scientific problems that require long time baselines such as determining the orbits of Solar System objects or binary stars are generally more appropriate for ground-based observations, since only a short arc of their orbital paths can be observed during the lifetime of a space mission. However, Hipparcos did discover many stars whose non-linear proper motions produced a valuable list of suspected binaries that have been ob-

[1]Yale University, New Haven, CT 06520 USA. (william.vanaltena@yale.edu).

[2]Departamento de Astronomía, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Casilla 36-D, Santiago, Chile. (rmendez@u.uchile.cl).

served from the ground during the past decade. It is likely that this experience will be repeated with Gaia except that the data volume will be 10,000 times greater, the precision about 100 times better and the limiting magnitude some 10 magnitudes deeper. It is staggering to consider the astrometric discoveries that await this new generation of astrometrists even when one considers the limited time domain for Gaia.

The volume of data available to explore both new and old scientific problems has expanded greatly in the past years so that currently there is little difference between new space missions, such as Gaia, and the largest of the ground-based telescopes with significant astrometric capabilities. In both cases it will be possible to sift through terabytes of data searching for positions, proper motions, parallaxes, magnitudes as well as other characteristics of astronomical objects. These enormous volumes of data will require the use of advanced analysis techniques as well as expanding our knowledge and use of modern statistical methods.

2. CONCLUSIONS

To prepare students for these dramatic changes in the techniques required for modern research astrometrists, I joined with an international group of 27 experts from 15 different countries to prepare a new introductory text in astrometry: "Astrometry for Astrophysics: Methods, Models and Applications", which was published by Cambridge University Press in 2013. The text is divided into five parts.

Part one provides the impetus to study astrometry by reviewing the opportunities and challenges of micro-arcsecond positions, parallaxes and proper motions that are being obtained by space astrometry missions as well as ground-based telescopes that are now yielding milli-arcsecond data for enormous numbers of objects.

Part two includes introductions to the use of vectors, the relativistic foundations of astrometry and the celestial mechanics of n-body systems, as well as celestial coordinate systems and positions.

Part three introduces the deleterious effects of observing through the atmosphere and methods developed to compensate or take advantage of those effects by using techniques such as adaptive optics and interferometric methods in the optical and radio parts of the spectrum.

Part four provides introductions to selected topics in optics and detectors, statistical methods in astrometry, methods for analyzing the images formed by our telescopes and the relations necessary to project complex focal plane geometries onto the celestial sphere.

Finally, part five highlights applications of astrometry to a variety of astronomical topics of current interest to stimulate students and researchers to further explore this exciting field. The figures and tables in the book are available for download at the Cambridge University Press site: (`http://www.cambridge.org`). A search on that site for "Astrometry for Astrophysics" will bring up the book site and the figures and tables can be found under the tab "Resources".

REFERENCES

van Altena, W. F. 2013, Astrometry for Astrophysics, by William F. van Altena, Cambridge, UK: Cambridge University Press