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The New Generation of Astrometrists.

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(Read by R. Mendez)

When we imagine what the next generation of astrometrists will need to prepare them for the new technologies we need to consider both ground and space observations. The most obvious limitation on space instrumentation is the relatively short time domain that it samples. However, we must keep in mind that the Hubble Space telescope was launched in 1990 and is still producing valuable high precision data nearly a quarter of a century later. What was initially planned to last relatively few years has turned into a very extended and extraordinarily productive scientific mission. Other space satellites have had rather shorter lifetimes such as Hipparcos 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. On the other hand, ground based telescopes generally have lifetimes of many decades. These different time domains 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 the determination of the orbits of Solar System objects or binary stars are generally dealt with better through 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 provide important data points in the orbits of widely separated binaries. In addition, through the measurement of non-linear proper motions of unresolved binaries it produced a valuable list of suspected binaries that have been observed 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!

A second area of change is in the volume of data available to explore both new and old scientific problems. When it comes to the volume of data, there is little difference between the 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.

We need to consider two areas of preparation that differ dramatically from the past: 1) the precision and accuracy of the observations; and 2) the volume of data that must be analyzed to solve various research problems. To prepare students for these dramatic changes in the techniques required to become modern research astrometrists I joined with an international group of 27 experts from 15 different countries to prepare an introductory text in astrometry. The resulting text was “Astrometry for Astrophysics: Methods, Models and Applications” 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 will be obtained by the new 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 following site under the tab "Resources" (http://www.cambridge.org/us/academic/subjects/astronomy/astrophysics/astrometry-astrophysics-methods-models-and-applications).