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THE FUTURE OF ASTROMETRIC EDUCATION

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RESUMEN

La Astrometría está preparada para entrar en una era de crecimiento y relevancia sin paralelo debido a la esperada abundancia de datos procedentes de las misiones espaciales *SIM* y *GAIA*. Se diseãn modernos telescopios terrestres, como el LSST, que brindaran datos menos precisos, pero de una mayor cantidad de estrellas. El potencial para los estudios de estructura, cinemática y dinámica de nuestra Galaxia, así como de la naturaleza física de las estrellas y de las escalas cosmológicas, no tiene igual en la historia de la astronomía. Es irónico, por lo tanto, que a escala global, se puede obtener una educación completa en astrometría sólo en San Petersburgo y en París, mientras que en breve, no se dictará curso alguno de astrometría en los EEUU. ¿Quién asegurará el control de calidad astrométrico de *JWT*, *SIM*, *GAIA*, LST, por no hablar de los grandes telescopios basados en tierra tales como, VLT, Gemini, Keck, NOAO, Magellan, LBT, etc.?

Proponemos una renovación de la educación universitaria en astrometría con el fin de preparar científicos calificados que permitan maximizar los resultados de las actuales inversiones multi millonarias en instrumentación astronómica. Por un lado, las agencias de financiamiento están proporcionando fondos especiales para estos propósitos, y a su vez, las universidades y los observatorios deben reconocer su responsabilidad de contratar astrómetras altamente calificados a fin de entrenar estudiantes y supervisar el instrumental astronómico planificado y existente, de tal manera que se obtengan y analicen datos de gran calidad.

Una solución provisional a este problema es proponer la realización de series de escuelas internacionales de verano en Astrometría. El Centro Científico Michelson del proyecto *SIM* coordinará una escuela de astrometría en 2005, a fin de iniciar este proceso. Se sugiere el equivalente a un programa educativo de un semestre en técnicas astrométricas en carreras asociadas con la astrofísica moderna.

ABSTRACT

Astrometry is poised to enter an era of unparalleled growth and relevance due to the wealth of highly accurate data expected from the *SIM* and *GAIA* space missions. Innovative ground-based telescopes are planned, such as the LSST, which will provide less precise data, but for many more stars. The potential for studies of the structure, kinematics and dynamics of our Galaxy as well as for the physical nature of stars and the cosmological distance scale is without equal in the history of astronomy. It is therefore ironic that worldwide it is possible to obtain an extensive education in astrometry only in St. Petersburg and Paris and in two years not one course in astrometry will be taught in the US. Who will ensure the astrometric quality control for the *JWT, SIM, GAIA*, LSST, to say nothing about the current large ground-based facilities, such as the VLT, Gemini, Keck, NOAO, Magellan, LBT, etc.?

We propose a renewal of astrometric education in the universities to prepare qualified scientists so that the scientific returns from the investment of billions of dollars in these unique facilities will be maximized. The funding agencies are providing outstanding facilities. The universities, national and international observatories and agencies should acknowledge their responsibility to hire qualified full-time astrometric scientists to teach students and to supervise existing and planned astronomical facilities so that quality data will be obtained and analyzed.

A temporary solution to this problem is proposed in the form of a series of international summer schools in Astrometry. The Michelson Science Center of the *SIM* project will hold an astrometry summer school in 2005 to begin this process. A one-semester syllabus is suggested as a means of meeting the needs of Astronomy by educating students in astrometric techniques that might be most valuable for careers associated with modern astrophysics.

Key Words: **ASTROMETRY — SOCIOLOGY OF ASTRONOMY**

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1. INTRODUCTION

The field of astrometry entered an era of dramatic change with the launches of *Hipparcos* and the *HST* in 1989 and 1990. These two remarkable satellites fundamentally changed the way that we look at our field, the types of research that are now feasible and our current suite of ground-based instrumentation. We need to develop a strategy for optimizing research opportunities with the next generation of astrometric space missions such as *SIM* (2010) and *GAIA* (2011), as well as with the large ground-based facilities that are planned. These opportunities obliged us to assume responsibilities for insuring the success of the astrometric portions of the missions and facilities and for educating astronomers who will use those instruments creatively and analyze the data with rigor. We need to be mindful that individuals whose primary research focus is in fields other than astrometry will be anxious to exploit this extraordinary data and need training in some aspects of classical astrometry. In addition, many of us will need education into the special techniques required to deal with advanced optical systems and the analysis methods for dealing with extremely large volumes of data.

2. SUCCESSES AND FAILURES IN ASTROMETRY

Hipparcos and the *HST* were eventually classed as being outstandingly successful, since they employed full-time astrometric specialists dedicated to optimizing and maintaining the instrumentation and data pipelines for astrometry. The astrometric calibrations of the KPNO mosaic camera and the *HST* Advanced Camera for Surveys were left unaddressed for years until outside astrometrists solved the problem. In both cases, several papers were published with severely compromised astrometry. It is rather ironic that institutions with annual budgets measured in the tens of millions of dollars could not afford to hire someone with astrometric skills to calibrate their instruments.

When we look at the near-term future, where Gigapixel cameras with hundreds of independent CCD chips, it should be obvious that the calibration at Gpx cameras will be extraordinarily complex, especially when a wide-field corrector with significant optical field-angle distortion is added. Data pipelines are another area where astrometric expertise is required to ensure the proper handling and calibration of the data.

3. WHERE IS ASTROMETRY TAUGHT?

Let us turn now to a review of the "pool" of astrometric talent available for the next generation of large telescopes. We have polled the institutions where educational programs from which scientists might come with good backgrounds in astrometry. Optimism about the future of education in astrometry is low everywhere except in France and Russia, where extensive educational programs in astrometry exist. In Latin America, Astrometry continues to be taught in Argentina, Brazil and Chile, but very few funds are available to support research in the field. Astrometric education has been terminated at five US institutions and near-term retirements may terminate the programs at another three institutions, leaving only two where some astrometry is taught. In fact, the only full-term course in astrometry regularly taught in the US during the past decade has been at Yale, while others devote only a few lectures to astrometric techniques in a course on observational astronomy.

4. LOOKING TO THE FUTURE

We face a very troubling future for astronomy. Too few students are being educated with the knowledge and skills in astrometry to support existing and future projects. We propose a temporary solution to this problem in the form of a series of international summer schools in Astrometry. The Michelson Science Center of the *SIM* project will hold an astrometry summer school in 2005 to begin this process. We have drafted a one-semester syllabus (van Altena & Stavinschi, 2005) to meet the needs of Astronomy by educating students in astrometric techniques most valuable for careers associated with modern astrophysics.

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