

## Space Astrometry in the Next Decade

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**Abstract.** A number of space astrometry missions have been proposed and planned for the next decade, as follow up to the highly successful Hipparcos space astrometry mission (1989-1993). These include DIVA, AMEX (SMEX), AMEX (MIDEX), FAME, JASMINE, SIM-PlanetQuest, Gaia, and OBSS. The capabilities and current status these missions is presented.

### 1. Introduction

Hipparcos is the world's first, and up to this point only, dedicated space astrometry mission. Owing in part to the great success of the Hipparcos mission, a number of follow-up space astrometry missions have been discussed, planned, proposed, funded, scheduled for launch, rescoped, descoped, and in some cases, cancelled. It is often difficult to keep track of the current status of the various space astrometry missions due in part to the quickly changing nature of the organizational priorities and funding resources of the major national and international space astronomy agencies. This manuscript provides a brief description and status of a number of space astrometry missions, beginning with Hipparcos.

### 2. Hipparcos

- **Synopsis:** First and only dedicated astrometric space mission. Hipparcos was highly successful, despite the failure to achieve the planned orbit. The great success of Hipparcos has spawned the new generation of space astrometry missions described in this manuscript.
- **Acronym:** High Precision Parallax Collecting Satellite
- **Funding Agency:** European Space Agency (ESA)
- **Launch:** Aug 08, 1989. Operations terminated Aug 15, 1993.
- **ConOps:** Continuous scanning. Two optically combined fields of view.
- **Number of Objects:** 120,000 (Hipparcos),  $2.5 \times 10^6$  (Tycho-2).
- **Magnitude Range:** 0-12.5  $m_v$  (Hipparcos), 0-12<sup>th</sup>  $m_v$  (Tycho-2)
- **Astrometric Accuracy:** 1 mas @ 9<sup>th</sup> (Hipparcos), 7 mas @ 9<sup>th</sup> (Tycho-2).

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- **Additional Information:** <http://astro.estec.esa.nl/Hipparcos>

### 3. FAME

- **Synopsis:** A NASA Medium Explorer (MIDEX) mission. NASA support was withdrawn in January 2002 after completing a preliminary design review, due to uncertainty surrounding detector development, and significant mission cost growth. FAME would have provided a bridge between Hipparcos and higher accuracy missions like Gaia, SIM, and OBSS.
- **Acronym:** Full-sky Astrometric Mapping Explorer
- **Funding Agency:** National Aeronautics and Space Administration (NASA)
- **Launch:** November 2004 (Planned). Five year mission.
- **ConOps:** Continuous scanning. Two optically combined fields of view.
- **Number of Objects:**  $40 \times 10^6$  stars
- **Magnitude Range:** 5-15<sup>th</sup> m<sub>v</sub>
- **Astrometric Accuracy:** 50 microarcseconds @ 9<sup>th</sup> magnitude
- **Additional Information:** <http://www.usno.navy.mil/FAME>

### 4. DIVA

- **Synopsis:** A relatively low cost bridge between Hipparcos and higher accuracy missions like Gaia, SIM, and OBSS, DIVA was cancelled in January 2003, due to a moderate funding shortfall. DIVA had progressed through the preliminary design review stage.
- **Acronym:** Deutsche Interferometer für Vielkanalphotometrie und Astrometrie
- **Funding Agency:** Deutsches Zentrum für Luft und Raumfahrt (DLR)
- **Launch:** 2006 (Planned). Two year mission
- **ConOps:** Continuous scanning. Two optically combined fields of view.
- **Number of Objects:**  $40 \times 10^6$  stars
- **Magnitude Range:** 5-15<sup>th</sup> m<sub>v</sub>
- **Astrometric Accuracy:** 200 microarcseconds @ 9<sup>th</sup> magnitude
- **Additional Information:** In addition to the sky mapper (astrometric) survey, DIVA was to produce a spectroscopic survey of the brightest 12 million stars and a UV survey of 15 million and 30 million stars at short and longer UV wavelengths, respectively. See: <http://www.ari.uni-heidelberg.de/diva/diva.html>

## 5. AMEX (SMEX)

- **Synopsis:** AMEX was a mission proposed to the NASA Small Explorer (SMEX) program. The proposed AMEX program involved an international collaboration, jointly funded by the DLR and NASA. AMEX was primarily based on the DIVA design. A proposal to perform an AMEX concept study was rejected by NASA administrators.
- **Acronym:** Astrometric Mapping Explorer
- **Funding Agency:** NASA & DLR
- **Launch:** 2007 (proposed). Three year mission.
- **ConOps:** Continuous scanning. Two optically combined fields of view.
- **Number of Objects:**  $40 \times 10^6$  stars
- **Magnitude Range:** 7-15<sup>th</sup> m<sub>v</sub>
- **Astrometric Accuracy:** 200 microarcseconds @ 9<sup>th</sup> magnitude

## 6. AMEX (MIDEX)

- **Synopsis:** The U.S. Naval Observatory, in collaboration with NASA-JPL, has continued to develop a more capable version of the DIVA and AMEX (SMEX) mission concept, intended to be proposed to the NASA MIDEX program. Due to changing institutional priorities, in Feb 2004 NASA announced that the next MIDEX proposal opportunity would be delayed at least a year. Instrument design, development, and costing activities, along with detector and reduction software development continue.
- **Acronym:** Astrometric Mapping Explorer
- **Funding Agency:** NASA (potential)
- **Launch:** 2009 (potential), 5 year mission
- **ConOps:** Continuous scanning. Two optically combined fields of view.
- **Number of Objects:** more than  $40 \times 10^6$  stars
- **Magnitude Range:** 7 to fainter than 15<sup>th</sup> m<sub>v</sub>
- **Astrometric Accuracy:** approximately 100 microarcseconds @ 9<sup>th</sup> mag.

## 7. JASMINE

- **Synopsis:** JASMINE is a Japanese infrared space astrometry satellite, operating at near-IR wavelengths.
- **Acronym:** Japanese Astrometry Satellite Mission for Infrared Exploration

- **Launch:** 2013-2015 (potential). Five year mission lifetime.
- **ConOps:** Continuous scanning, galactic plane. Two optically combined fields of view.
- **Number of Objects:** a few  $100 \times 10^6$
- **Astrometric Accuracy:** 10 microarcseconds at  $m_z = 15.5$  or  $K=12^{th}$
- **Additional Information:** <http://www.jasmine-galaxy.org/>

## 8. SIM PlanetQuest

- **Synopsis:** SIM PlanetQuest is a space-based optical interferometer operating in an Earth-trailing orbit. Currently, SIM and Gaia are the only fully-funded space astrometry missions.
- **Acronym:** Space Interferometer Mission
- **Funding Agency:** NASA
- **Launch:** 2010 (planned). Five year baseline mission, potential ten year extended mission.
- **ConOps:** SIM PlanetQuest is a pointed mission with predefined targets
- **Number of Objects:** about 10,000 stars (1,300 grid stars)
- **Magnitude Range:** brighter than (a limiting magnitude of) about  $20^{th}$ .
- **Astrometric Accuracy:** 4 microarcseconds wide angle, 1 microarcsecond narrow angle
- **Additional Information:** SIM PlanetQuest is currently in mission development Phase B (Preliminary Design phase). See: <http://planetquest.jpl.nasa.gov/SIM>

## 9. Gaia

- **Synopsis:** Gaia is a funded space astrometry mission intended to launch in 2010-2012. Operating at L2, Gaia consists of three instruments which provide astrometric, photometric, and spectroscopic data.
- **Funding Agency:** ESA
- **Launch:** before 2012 (planned). Five year operation phase.
- **ConOps:** Continuous scanning. Two optically combined fields of view.
- **Number of Objects:**  $10^9$
- **Magnitude Range:**  $7-20^{th}$  magnitude

- **Astrometric Accuracy:** 10 microarcseconds @  $15^{th}$   $m_v$
- **Additional Information:** In addition to astrometry, Gaia will provide 12 band millimagnitude photometry, radial velocity data for brighter stars to an accuracy of a few km/s and spectrophotometry in the visible and near-IR to  $m_v$  17.5. See: <http://www.rssd.esa.int/gaia/>

## 10. OBSS

- **Synopsis:** The U.S. Naval Observatory, in collaboration with NASA-JPL, are currently funded to investigate, study, and develop the OBSS mission as a possible future mission concept within the NASA Astronomical Search for Origins Program. There are three implementations currently under study; a spinning telescope (OBSS-A), a pointed telescope (OBSS-B) and an near-IR telescope (OBSS-C).
- **Acronym:** Origins Billion Star Survey
- **Funding Agency:** NASA
- **Launch:** next decade (potential).
- **ConOps:** Continuous scanning (OBSS-A, -C). Pointed (OBSS-B)
- **Number of Objects:**  $10^9$
- **Magnitude Range:** Depends upon implementation
- **Astrometric Accuracy:** Depends upon implementation
- **Additional Information:** <http://www.usno.navy.mil/OBSS>