THE JOINT MILLI-ARCSECOND PATHFINDER SURVEY (J-MAPS): MISSION OVERVIEW

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ABSTRACT

We describe the Joint Milli-Arcsecond Pathfinder Survey (J-MAPS). J-MAPS is an all-sky space-based astrometric survey mission with a primary mission objective of measuring stellar positions and motions to better than 1 milliarcsecond (mas) and 1 mas per year, respectively. J-MAPS will completely update the Hipparcos catalog (1 mas @ epoch=1991.25; 16 mas @ epoch=2006) and the twenty year baseline between the two missions will allow for extremely accurate proper motion measurements (< 0.1 mas/year), making the catalog viable for decades. The J-MAPS catalog will support future high-accuracy orientation users as well as providing a high-accuracy (20 cm @ GEO), high density (>100 stars per square degree) optical reference grid tied to the International Celestial Reference Frame (ICRF) to support current and future ground and space-based SSA assets. J-MAPS will also serve as a technology pathfinder for future space technologies such as very large format active pixel sensor (APS) detectors, high accuracy GPS, advanced processing electronics and next generation star trackers. Finally, J-MAPS will provide a wealth of unique astrometric and photometric data for the nearest ten million stars that will support astronomy and astrophysics research in such fields as extra-solar planet detection, galactic dynamics and basic cosmology.

1. INTRODUCTION

Astrometry is the precise measurement of the positions and motions of celestial objects. Astrometry data supports both basic research and a variety of civilian and defense applications. Precise measurement of stellar motions can reveal, for example, the presence of planets around stars, streams of stars in the galaxy that are remnants of previously cannibalized galaxies, etc. Applications for the data include the generation of star catalogs for use by star trackers in support of spacecraft attitude determination subsystems and providing a reference grid of background stars for measuring positions of resident space objects from both ground and space-based sensors.

The European Space Agency's (ESA) Hipparcos mission [1] was the first—and so far, only—space-based astrometry mission. Prior to Hipparcos, all optical astrometry was performed from the ground and necessitated observation through the turbulent atmosphere. Ground based catalogs have been typically limited to 20—30 milliarcseconds (mas)[1] at best, with many ground based catalogs having accuracies closer to 100 mas. Hipparcos, by observing above the atmosphere, was able to improve accuracies by one to two orders of magnitude, with a final mission accuracy of approximately 1 mas (position) and 1 mas/year (proper motion) for stars in its primary observing range of 1^{st}-7^{th} magnitude.

Because of the error in proper motion, however, the data have degraded in the intervening years. Hipparcos position data that was accurate at the 1 mas level at epoch 1991.25 (the Hipparcos mean epoch), has degraded to ~16 mas for the 2006 epoch, and will degrade to 25 mas by 2015.

While this suffices for most current applications, Hipparcos-based catalogs will not be able to support future needs and requirements for both accuracy and densities (stars per square degree of sky). The Joint Milliarcsecond Pathfinder Survey mission (J-MAPS, see Fig. 1) is being developed to address this need. J-MAPS is a small, dedicated astrometric all-sky survey satellite that will produce a 1 mas astrometric catalog for epoch 2010 through 12^{th} magnitude (with degrading accuracy to 15-16^{th} magnitude), and a catalog that is at least 100 times denser than Hipparcos. When combined with the Hipparcos position measurements, the proper motion of the118,000 stars that are shared will be determined to better than 100 *micro*-arcseconds per year

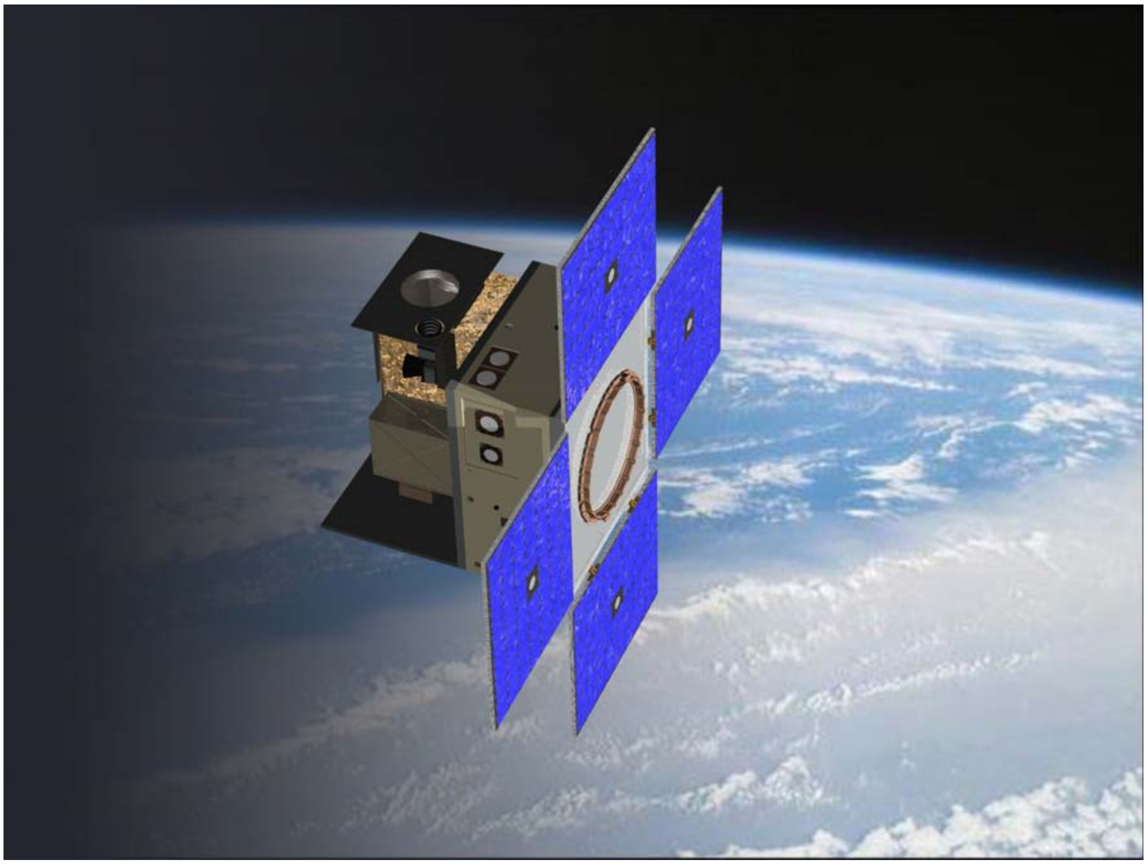

Figure 1. J-MAPS satellite in 900 km SSO orbit.

In addition to supporting catalog development for orientation users, the mission has multiple secondary objectives. These include providing an optical reference grid (tied to the International Celestial Reference Frame (ICRF)) of accuracy 20 cm at GEO to support both ground and space-based SSA measurements, the development of new technology up to the TRL 7 level, and demonstrating the usefulness of an astrometric

[1] 1 arcsec ≈ 5 x 10^{-6} radians; 1 mas ≈ 5 x 10^{-9} radians

instrument in space for augmenting current and planned SSA measurement capabilities. In addition, the resultant stellar position and—in particular—stellar motion data will enable basic research into a variety of cutting edge astronomy and astrophysics topics of interest.

In this paper, we provide a mission overview (§2), followed by descriptions of orientation applications (§3), SSA applications (§4), and astronomical applications (§5). We next provide a brief description of some of the technology pathfinding (§6), followed by a discussion of current status (§7) and the summary and conclusions ((§8). References are provided in §9.

2. MISSION OVERVIEW

The baseline mission concept for J-MAPS is as follows: the instrument (see Fig. 2) is a 15 cm aperture, f/25 four mirror anastigmat (FMA) optical telescope with reflective elements only. The focal plane consists of a single 8k x 8k Complimentary Metal Oxide Semiconductor (CMOS)-Hybrid Active Pixel Sensor (APS) detector running at -80 C (193 K). On board digitization and data processing is accomplished by a dedicated set of electronics located in the Camera Electronics Box (CEB). Total instrument mass is approx. 30 kg and orbit averaged power is approx. 100 W.

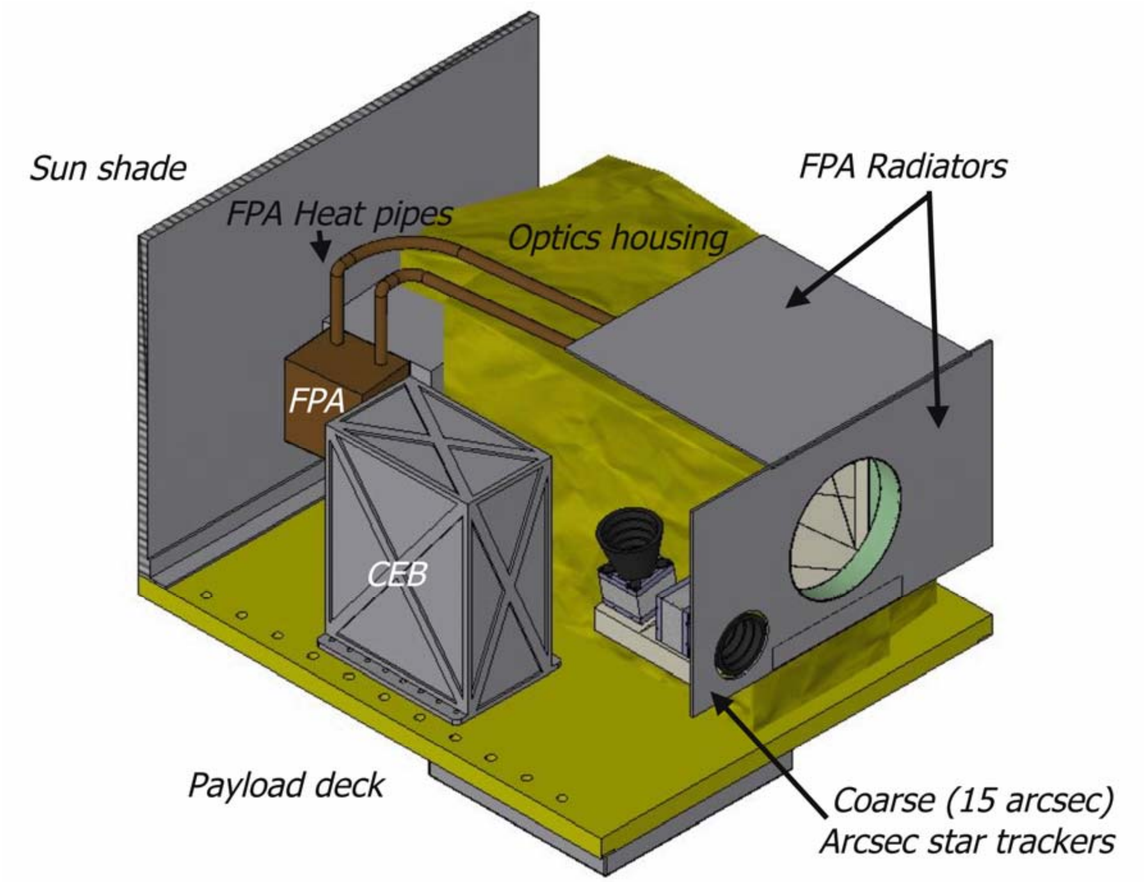

Fig. 2. J-MAPS Instrument Payload

The instrument is deployed on a payload deck approximately 2' x 2' in area, which is secured to a microsat bus (see Fig. 3). The bus houses the Global Positioning System (GPS) receivers required for high accuracy position and velocity determination, solar panels for electrical power generation, the communications subsystem, and the attitude control subsystem, including reaction wheels, torque rods, and magnetometer. The bus includes an EELV Secondary Payload Adapter (ESPA) ring for mounting on secondary slots for STP launches.

J-MAPS is a step-stare imager that observes the entire sky multiple times over the course of its mission. Each one square degree field of view is observed for twenty seconds; the spacecraft then spends the next ten seconds slewing and settle to the next field, typically offset by 0.5 degrees from the previous

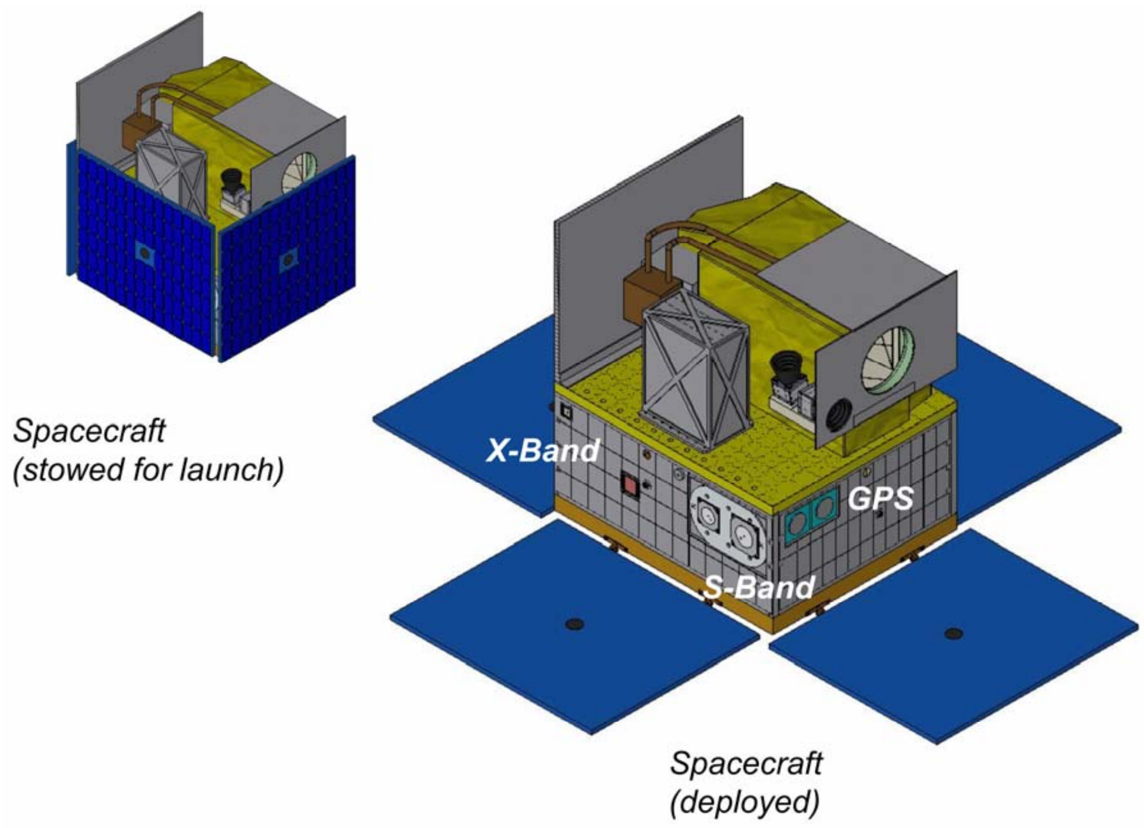

Fig. 3. J-MAPS Instrument and Bus.

one. Special observations are made for very bright stars (multiple observations at short exposures) and for faint, extra-galactic tie objects (long exposures up to 100 sec). Fine determination of the spacecraft attitude is done by non-destructively reading out windows around approximately ten guide stars per field at a 5 Hz frame rate, and developing an attitude solution good to 50 mas or better. This attitude solution is then used to drive the J-MAPS attitude control system and maintain pointing at the required level.

J-MAPS observes over a dynamic range of approximately 2^{nd} to 15^{th} magnitude. This is accomplished by using field-appropriate integration times over the range 0.1—100 seconds and taking advantage of both the non-destructive read and selective reset capabilities available with a CMOS-Hybrid sensor. J-MAPS will achieve single measurement accuracies of 5 mas per axis for stars through 12^{th} magnitude, with resultant mission accuracies of 1 mas or better for the same stars.

3. ORIENTATION APPLICATIONS

J-MAPS will produce a 2010-epoch catalog that will support very high accuracy attitude users for many years to come. The output catalogs will cover the magnitude range 2—12 at a mission accuracy of 1 mas in position. In addition, stars as deep as 16^m will be observed at reduced accuracy (due to photon statistics). The J-MAPS catalog will be deeper than Hipparcos, with approximately 100 times its density in terms of stars per square degree. Astrometric information will be supplemented by standard astronomical photometry (color) information, which will allow the generation of instrument-specific catalogs at arbitrary bandpasses in the visible and NIR portions of the spectrum. In addition, observation of all 118,000 stars shared with Hipparcos will, due to the nearly 20 year temporal baseline, allow for determination of stellar proper motions approximately 20 times better than possible from just Hipparcos (<0.1 mas/year), meaning that the J-MAPS catalog will degrade much more slowly than the Hipparcos catalog.

J-MAPS will also serve as a prototype 10 mas star tracker. This represents an order of magnitude improvement in attitude determination capabilities vs. the best current star trackers. J-MAPS will pathfind both the technology and operating concepts that will enable star tracker technology to make a significant leap in accuracy.

4. SPACE SITUATIONAL AWARENESS (SSA) APPLICATIONS

J-MAPS supports SSA in two different ways: 1) generation of a 20 cm (@GEO) optical reference grid, and 2) capability demonstration of an astrometric instrument for SSA observations in space. We discuss each of these in turn (see also [2]).

Orbit determination for an RSO using a passive optical system requires measuring the position of the RSO against a fixed reference frame. As noted previously, the best current optical reference frame is from Hipparcos (3 m @ GEO), but the number of stars in the Hipparcos catalog is sparse (~2.5 per square degree), making its use for SSA highly problematic. Other catalogs with denser grids (such as the UCAC or USNO-B catalogs) have significantly reduced accuracies. J-MAPS will provide a 20 cm reference grid tied to the ICRF at a density sufficient to be readily utilized by many current and planned SSA assets, enhancing their ability to accurately determine orbits. Tying individual instrument and platform SSA observations to the standard astronomical reference frame allows for measurements of absolute positions and facilitates the transfer of positional information between platforms.

The second application is as an SSA demonstration system. Current and planned optical SSA systems are tasked with both "finding" and "fixing" the location of RSOs. For obvious reasons, these assets are optimized for the detection task. Optimizing for detection typically involves increasing the signal-to-noise ratio (SNR) by significantly undersampling the optical point spread function (PSF). This is a trade in that once the sampling of the PSF drops below ~2 pixels full width half maximum (FWHM), spatial information is lost and the ability to determine where an object is within a pixel diminishes rapidly. Highly undersampled systems have high SNRs, but very poor centroiding.

The J-MAPS instrument, by contrast, is optimized for positional measurements at the expense of some SNR in the central pixel. Because of this, J-MAPS will be able to measure positions of RSOs an order of magnitude better than current or planned systems. The accuracy of these measurements will allow the calculation of orbits in a matter of mintues rather than hours that are currently typical. When combined with the 1 mas optical reference grid that will be generated by J-MAPS observations and the on-board next generation GPS system, absolute measurements at the 10 m level (plane-of-sky) are possible. J-MAPS will demonstrate the ability of a space-based astrometric instrument to augment the current and planned SSA architecture and provide a crucial new source of information for future SSA warfighters in terms of the ability to rapidly and accurately measure positions, determine orbits and detect hostile maneuvers.

5. ASTRONOMICAL AND ASTROPHYSICAL APPLICATIONS

Over three-thousand refereed journal articles published in the major astronomical literature have made use of Hipparcos data in one way or another. The scientific harvest of the J-MAPS mission, like that of the Hipparcos mission before it, will be extraordinary, not only in terms of scientific extent but also scientific implications and impact. The Science topics synopsized in this document are examples of but a few areas in which the J-MAPS mission will have a significant, immediate, and unique impact. However, no claim for completeness is made.

5.1 Planets and brown dwarfs

Extrasolar planetary systems may be quite common, but those discovered to date do not bear much in common with the Solar system. Most of the known extrasolar planets are believed to be massive, hot blobs of gas orbiting their host stars in tight, usually eccentric orbits. One of NASA's strategic goals for the 2006-2016 timeframe is to "*…search for Earth-like planets.*" Toward this end, NASA "*…will complete the activities necessary to prepare the Space Interferometry Mission (SIM) for implementation. The SIM project will search for Earth-like planets orbiting nearby stars and measure the precise positions of these stars to enable accurate mass determinations of any planets that orbit them*." (ref: 2006 NASA Strategic Plan, Sub-goal 3D). Based on models of exosolar systems, it is believed a Jupiter-like planet in a ~5AU orbit serves as a signpost for extrasolar systems with a higher likelihood of containing Earth-like planets. Unfortunately, Jupiter-like planets in ~5AU orbits are difficult to detect due to their long periods and a small radial velocity variation of the host star. J-MAPS has the capability to detect a significant number of extrasolar, long period Jupiter-like planets. Shorter-period Jupiter-like planets (P ~ 2 years) can be detected during the baseline 2 yr-mission, if a significant fraction of observing time is dedicated to observing nearby stars in the differential regime, taking advantage of the pointing mode of the telescope. J-MAPS can detect Jupiter-like planets at 3σ level around nearest stars out to distances ~ 5 pc, if its mission time is extended to 5 years. The detection of extrasolar planetary systems with Jupiter-like planets will greatly increase the observing efficiency of SIM in its search for Earth-like planets. The J-MAPS mission can optimize the SIM target list, maximizing the probability that SIM will detect a number of Earth-like planets.

In addition to its ability to detect Jupiter-like planets, J-MAPS will also be sensitive to the presence of substellar-mass objects (brown dwarfs) around nearby solar-type stars out to 5—100 pc, depending on the mass of the companion and the mission length. J-MAPS will definitely resolve the issue whether the paucity of substellar companions in binary systems (the brown dwarf desert) extend into the domain of long orbital periods and M-type primaries.

5.2 Survey of nearby stars

Nearby stars are prime targets for extrasolar planet research and the quest for other habitable worlds. Nearby stars are also important test objects for basic theories and models of modern astrophysics, such as Galaxy star formation history, the local luminosity function, initial mass function and the final stage of stellar evolution, all of which contribute to Sub-goal 3D of the 2006 NASA Strategic Plan: *Discover the origin, structure, evolution, and destiny of the universe, and search for Earth-like planets*. It has been demonstrated that the accuracy of current radial velocity programs is sufficient to detect Neptune-mass planets around nearby M dwarfs. According to the NASA RECONS electronic database, the number of missing stellar systems within 10 pc is 130. The majority of them are dwarfs of spectral type M. The ongoing vigorous search for nearby stars is focused on high proper motion stars; with distances estimated spectroscopically or photometrically. J-MAPS will detect most of the missing nearby M dwarfs down to V=16 mag by directly observing their parallaxes in the global survey mode to better than 10%. This search is irrespective of proper motion, so that nearby stars with slow motion will not escape detection. Distances to already known systems within 10 pc will be observed to better than 1% in he dedicated survey mode. The intriguing issue of very wide, common proper motion pairs among nearby stars will be resolved. J-MAPS will yield a Gliese catalog (d < 25 pc) complete with all solar-type stars. Many nearby white dwarfs will be discovered by J-MAPS. The number of identified enigmatic subdwarfs, which are difficult to detect without accurate parallaxes, will greatly increase.

5.3 Nearby young stars

Beyond the study of the nearest stars, discussed in the previous section, the solar neighborhood (within 100 pc) includes hundreds of stars considerably younger than the Pleiades (~75 Myr). These stars range in spectral type from early A to late M. Their origins, physics of formation and exact ages are not known. Many of them appear to be members of extended dynamically loose mini-associations and moving groups; others are completely isolated. These stellar systems, thanks to their proximity and youth (ages between 7 and 50 Myr) are the best objects for an investigation of the chronology of planetary formation in the wide range from terrestrial to giant planets. For example, the recently identified AB Dor group partly engulfs the Sun, and is ~50 Myr old. If the current understanding of how and when planets form around stars is correct, the whole complement of planets should be found in the AB Dor group, including Earth-mass planets. But more accurate ages for these stars are needed along with a better understanding of the circumstances of their creation. J-MAPS will enable determination of the origins of these stars to 0.13—4.7 pc and will reveal if they were ejected from nearby clusters or OB associations, or were formed *in situ* due to recent supernova explosions or molecular cloud collisions. Many new association members will be found in the global survey regime, and the database of quality parallaxes (to ~0.5 mas) will be extended by a factor of 5, including many young M dwarfs which were missed by Hipparcos. The M dwarfs will yield accurate ages by isochrone fitting. The origins of the nearest hot runaway stars will be investigated in depth.

5.4 Star forming regions and associations

Hipparcos observed only pre-selected stars included in the input catalog. Unfortunately, the Hipparcos input catalog did not include some of the nearest star forming regions such as R CrA, Chamaeleon, Ophiuchus, Orion and Taurus-Auriga. As a result, the ages and membership of pre-main sequence stars in these regions are poorly known and the distances are ill-defined, severely hampering knowledge of key parameters such as the initial mass function, and the pursuit of various investigations such as the mechanism of sequential star formation. Besides omission from the input catalog, the stars of many regions were too faint to be well observed by Hipparcos. For example, the vast majority of weak-lined T Tauri K- and M-type stars in the important Orion SFR were a little too faint (11—13 mag). In the dedicated survey mode, J-MAPS will obtain quality parallaxes, proper motions and, possibly, two- or three-color photometry for hundreds of pre-main-sequence stars in the selected star forming regions, down to the lowest stellar masses. This will place these stars on the HR diagram, will help to unambiguously determine the initial mass function, and will put to test the existing theory of stellar evolution at ages less than 10 Myr. The relation between isolated weak-lined T Tauri stars and high-Galactic latitude molecular clouds (MBM 16, MBM 19) will be revealed. By having very accurate differential proper motions for member stars down to V=15 mag in such regions as R Cra (to ~ 0.3 mas yr^{-1}), the internal dynamics of turbulent, star-forming giant molecular clouds will be measured for the first time. The vast majority of pre-main sequence and zero-age main sequence dwarfs in the Scorpius-Centaurus OB complex (d = 110—140 pc), missed by Hipparcos, will be accurately measured by J-MAPS, leading to breakthrough discoveries in the mechanism of generation of such huge stellar aggregates, and disentangling the dynamical history of this largest star formation event in the vicinity of the Sun.

5.5 Open clusters

Theoretically, dynamical evolution and structure of rich, Orion-type open clusters is believed to be well understood and well simulated. However, there is little observational evidence in support of these theories, in part because of the general deficit of accurate astrometric data, in part because of the emerging inconsistencies between theory and data. Internal velocity dispersions, estimated only for two clusters thus far (the Hyades and the Pleiades), seem to be smaller than predicted for a given total mass in a dynamically relaxed state. Evidence of mass segregation and binary segregation is strong to nonexistent. The binary formation rate varies widely between the clusters (e.g., the Pleiades and Alpha Persei). Empirical main sequences are scattered and sometimes twisted in the ultraviolet and in the near-infrared. The effects of stellar activity rotation and spottedness are poorly known. Some clusters are mantled in extended halos of co-moving stars or embedded in gravitationally unbound associations, of unclear origins. It is even doubted that member stars are truly coeval in open clusters. J-MAPS is positioned in time and capability to shed light on these issues. In the differential astrometry regime, J-MAPS will be able to determine internal velocities of stars to 21—90 m s^{-1}. For a few clusters of basic importance, memberships will be determined down to mid-M type, based on precision proper motions, parallaxes and photometry at ~0.01 mag accuracy. This will cover an unprecedented range of the mass function derived with a single, well-calibrated instrument. Estimation of astrometric radial velocities, mean trigonometric parallaxes, systemic rotation, halo evaporation, mass segregation, total dynamical mass, and binarity rate will be made for several clusters spanning 10—2500 Myr in age.

5.6 Galactic cannibalism

The Milky Way, like other large galaxies, is engaged in cannibalism of smaller neighbors that happen to wander too close to its gravitational well. Although rather clear evidence has been produced that this process is going on even now, it is not well known what role this phenomenon played in the original build-up of the Galaxy, in the formation of the Galactic halo, and segregation into the thick disk and thin disk. It is also a matter of theoretical and observations dispute what fraction of the current stellar population has been acquired through cannibalism. It has been realized that fossils of galactic mergers can retain a rather confined location in the orbital eccentricity – vertical momentum parameter space, for a long time. The simplest way to detect such mergers is to look for large moving groups on retrograde or high-inclination Galactic orbits, and investigate their chemical composition, which may bear telltale signs of extragalactic origin. Hipparcos simply observed too few stars to reach any firm conclusions, although some signs of retrograde streams have been reported. J-MAPS is ideally suited to make a remarkable contribution in these studies. It will enable the vetting of millions of field stars for peculiar kinematic streams, using the proper motions and parallaxes gathered in the global regime. Nearby dwarfs and distant giants can be discriminated by parallaxes, and by near-infrared colors, available from the 2MASS survey. A photometric capability of J-MAPS, precise to ~0.01—0.04 mag will facilitate classification of field stars. A rather detailed dynamical portrait of the local part of the Milky Way will emerge from J-MAPS data, along with the identification of a large number of halo stars.

5.7 Binary neutron stars and black holes

Neutron stars and low-mass black holes are endpoints of stellar evolution at masses above ~8 Msun, and they are not uncommon in the Galaxy. These exotic stellar endpoints often manifest themselves as X-ray binaries in very tight binary systems with a normal dwarf or giant stars companion; a number of radio pulsars have also been identified in stellar binaries. Detection and measurement of such systems, especially of wide orbiting binaries, is of crucial importance for direct determination of black hole and neutron star masses. J-MAPS will be quite sensitive to the reflex astrometric motion imparted on the visible stellar component by the invisible companion. The Hipparcos catalog lists ~ 20 distant (d > 1 kpc) stars with statistically significant accelerations of proper motions, which may include neutron star or black hole companions. For these relatively bright stars (V < 11 mag) observed in the special survey mode for 2 years, accelerations will be determined to ~1 mas yr^{-2}, well within the required accuracy to detect orbital motion of long-period systems. Systems with orbital periods somewhat shorter than 2 years can be fitted with a 12-parameter Keplerian model out to ~ 1 kpc, yielding the apparent size, inclination and period of the orbit, and an estimate of the mass of the invisible companion. A great number of stars, about which little is currently known, will be screened for orbital motion by J-MAPS in the global survey. This may prove a major discovery space for J-MAPS.

5.8 Cosmic distance scale

The mean distances for several open clusters, including the Pleiades, derived from Hipparcos trigonometric parallaxes, are in error by ~ 1 mas or more. There is little doubt now that the reason for this error is in faulty data reduction algorithms used for the Hipparcos mission, and that the overall astrometric performance could have been much better if correct, unbiased methods were used. Since the calibrated main sequences of nearby clusters are the basic parts of the cosmic distance scale, the whole pyramid of distance calibration in the Universe is partly suspect. Hipparcos results also contradict the theory of stellar evolution, which is one of the pinnacles of modern astrophysics. Beside parallaxes, other astrometric parameters are likely corrupted by sky-correlated errors too. J-MAPS will re-determine the distances to fundamental clusters (the Pleiades, Praesepe, Coma Berenices and the Hyades) and rectify the distance scale. J-MAPS is expected to achieve an 0.6 mas accuracy in the global parallax zero-point, an improvement of roughly a factor of 2 over Hipparcos. This accuracy is based on the direct tie to the extragalactic inertial reference frame made up of quasars, which helps to constrain parallax and proper motion solutions and reduce correlated errors. J-MAPS will also re-observe 220 classical Cepheids, for which Hipparcos obtained astrometry of limited value. J-MAPS is much better designed for observing variable stars in crowded regions. This will lead to a much larger database of statistically significant trigonometric parallaxes for Galactic Cepheids, than is available now, and to a more accurate empirical period-luminosity relation. Existing concerns that Cepheids in the Galaxy and in the Magellanic Clouds obey the same period-luminosity relation, or even have the same basic properties, will be resolved by direct observations.

6. TECHNOLOGY PATHFINDING

A secondary mission objective for J-MAPS is to develop and fly technology by 2010 that will benefit future defense and civilian space missions by raising the Technology Readiness Levels (TRL) of the relevant technology to level 6 or 7. This technology maturation will have significant benefits to future NASA and DoD missions in terms of reduced risk and cost and schedule constraint. The technology that J-MAPS will demonstrate includes very large format CMOS-Hybrid (or similar) APS detectors, with the H8RG-10 detector from Rockwell Scientific (RSC) as the current baseline; advanced Application Specific Integrated Circuits (ASIC) for digitization and initial processing of the data and for driving the detector readout circuitry (with the RSC Sidecare ASIC as the current baseline), next generation GPS receivers, IMUs and processor electronics. The mission will also serve as a pathfinder for development of a next generation, much higher performance star tracker. Finally, the ADCS system will be unique in terms of the requirements that are levied on a microsat bus. All of this technology development will benefit post-J-MAPS missions in the 2010-2020 timeframe.

7. CURRENT STATUS

J-MAPS is currently in a post-concept study risk reduction phase. USNO has procured a 4k x 4k version of the CMOS-Hybrid detector from RSC and together with Goddard Space Flight Center (GSFC), are building a ground test camera (GTC). The GTC will be deployed to the Naval Observatory/Flagstaff Station (NOFS) facility for sky testing in the early 2007 timeframe. Other current activity includes risk reduction studies for the on-board processing electronics, alternate optical designs, and development of a finite elements model to analyze vibrational modes of the full spacecraft (including payload) during on-orbit maneuvers.

8. SUMMARY AND CONCLUSIONS

J-MAPS is a space-based, all-sky astrometric and photometric survey from 2nd through ~15th magnitude with a 2010 launch date goal. The instrument consists of a 15-cm telescope, a large (64 megapixel) active pixel sensor focal plane, and associated processing electronics, carried aboard a microsatellite bus in a 900-km, sun-synchronous low earth orbit.

The primary mission goal for J-MAPS is the generation of a 1-milliarcsecond (mas) all-sky astrometric catalog for the 2010 epoch in support DoD space platform precise orientation needs for the next decade and later. The resultant optical reference grid will be available for all ground- and space-based optical SSA sensors, with a density of >100 stars per square degree and a resolution of 20 cm at GEO. In addition, J-MAPS will serve as a pathfinder for new technology in support of future space missions, including the very large format detector, the onboard processing electronics, and next generation space-based GPS-technology.

We have discussed the astronomy and astrophysics applications of J-MAPS. A 1-mas (or better) all-sky survey through approximately 15th magnitude will have a tremendous impact on our current understanding of the galaxy and stellar astrophysics. J-MAPS science topics include: a kinematic and photometric exploration of the nearest star forming regions and associations; an understanding of the dynamics and membership of nearby open clusters; a survey of nearby stars that addresses the 130 missing systems within 10 pc; recalibration of the cosmic distance scale via distances to nearby clusters and the period-luminosity relationship using high accuracy proper motion (Hipparcos and J-MAPS positions and a twenty year baseline) and parallax measurements; discovery of giant planets and brown dwarfs orbiting nearby stars; kinematic detection of galactic cannibalism and mergers in the Milky Way; and discovery of low-mass black holes and neutron stars in astrometric binaries.

9. REFERENCES

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