INFRARED WIDE-FIELD SURVEYS

N. EPCHTEIN
Observatoire de Paris
Département de Recherche Spatiale
F-92195 Meudon Principal Cedex
France

ABSTRACT. Optical wide-field sky surveys have long been basic tools of astronomical investigations. Their extension to the near infrared spectral range, unattainable with photographic techniques, is now possible thanks to the considerable improvements in infrared array technology that have been achieved in the past few years. The astronomical motivations for all-sky 2 μm surveys are summarized, and a brief technical description of the on-going projects, in particular DENIS (Deep Near Infrared Southern Sky Survey) that will be carried out at the European Southern Observatory in 1994-97, is presented.

1. Introduction

Twenty five years ago, the Two Micron Sky Survey (TMSS) (Neugebauer & Leighton 1969) showed that the near infrared sky looks completely different from the 'usual' optical sky. It is dominated by red giants, supergiants and long period variables (α *Ori* and R *Dor* are the brightest sources of the TMSS). Despite the low sensitivity level of the TMSS, many unknown objects were discovered such as the infrared carbon stars, *IRC* + 10216, that turned out to be one of the favourite targets for millimetric observations of molecular lines. The TMSS remains, even today, the only comprehensive list of 2 micron sources in the astronomical sky, and hundreds of articles have been based on this pioneering work.

The infrared detector performances have considerably improved since the achievement of the TMSS, especially during the past ten years, with the advent of large size panoramic detectors. An all-sky 2 micron survey superseding the TMSS by more than 4 orders of magnitudes in sensitivity can be achieved, now, in a reasonable amount of observing time (a few years), with the existing technology, and a standard one metre class telescope. This is the aim of the two major projects currently under implementation phases, namely 2MASS (Two Micron All Sky Survey) (Kleinmann 1992) in the US and DENIS (DEep Near Infrared Southern Sky Survey) in Europe. Both projects have received considerable interest among a wide community of astronomers and are strongly supported by the respective funding agencies. They will start operations in the very near future (1994 for DENIS). These surveys will extend the remarkable results obtained by the IRAS mission which was mainly aimed at an all sky survey in the 12 – 100 μm range, and will provide invaluable statistical information on badly known stellar populations and on the local structure of the Universe.

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2. Scientific Goals of the All-Sky IR Surveys

The basic mission of the new surveys is of exploratory nature. The creation of exhaustive and comprehensive documents in the infrared that will be comparable to the Schmidt Sky Surveys and the large stellar catalogues in the optical range will be of utmost interest for a wide community of astronomers and in particular those involved in the forthcoming infrared space missions that will be launched in the coming decade (ISO, NICMOS, SIRTF, etc.), as well as those involved in the programmes of the recent and future very large telescopes (ESO-VLT, Gemini, Keck, etc.).

Besides, a number of specific scientific programmes could be tackled with the new survey data. This spectral range has two main advantages with respect to the optical one: 1) it corresponds to the maximum of emission of the bulk of the stars that populate evolved galaxies (such as our Milky Way); 2) it is much less sensitive to the interstellar extinction which hides most of the central regions of our Galaxy, and notably its bulge (see, for instance, the near infrared composite prints provided by the COBE mission).

The $\approx$ 5500 sources detected during the TMSS basically consist of relatively nearby red giant stars, but the tens of millions of stars that the novel deep surveys will pick up will mainly consist of low luminosity red dwarfs. It is expected to single out most of the dwarf stars in a sphere of 100 pc radius around the Sun and, thus, to improve significantly the low luminosity side of the local luminosity function. There is also good hopes to uncover a significant number of very low mass stars. In addition, an exhaustive collection of several tens of thousands of red giant and supergiant stars, even in highly obscured areas of our Galaxy, will be detected. The combination of IRAS and near infrared colours will allow us to single out most of the high mass loss rate carbon stars and to investigate their space number density distribution in the Galaxy. A large number of young stellar objects or short-lived objects (bipolar flows, heating sources of molecular clouds, compact HII regions, young planetary nebulae, etc.) will be detected that will lead to improving the estimation of the *Initial Mass Function* and *Star Formation Efficiency* in different regions of the Galaxy.

Deep 2 μm surveys will be very sensitive to evolved galaxies (spiral and elliptical) that contain mainly red stars. Whereas there was essentially no external galaxy in the TMSS, the new surveys will detect hundreds of thousands of them and will provide a very comprehensive catalogue of nearby spiral and elliptical galaxies (up to $z = 0.2$) and, most importantly, this catalogue will cover regions of the sky that are hidden by the galactic interstellar extinction in the optical range. Our knowledge of the local structure of the Universe will undoubtedly take benefit from these new data.

3. The DENIS Project

The objective of the DENIS project is to cover the all southern sky (up to $\delta = +2°$) simultaneously in 3 photometric bands of the red/near infrared range, namely the *Gunn-i* ($\lambda = 0.82$ μm), the Johnson J ($\lambda = 1.25$ μm) and the *short-K* band ($\lambda = 2.15$ μm) (hereinafter I, J, K, respectively for the sake of simplicity). A dedicated 3 channel camera has been designed and built under the leadership of Paris Observatory and the management of Dr. D. Rouan, with the participation of Institut d'Astrophysique de Paris, the University of Innsbruck, the Instituto de Astroffsica de Canarias in Tenerife, the Istituto di Astrofisica Spaziale in Frascati and Lyons Observatory. This camera is equipped with three *state-of-the-art* detector arrays: a Tektronix CCD (1024 x 1024 pixels) for the I band and two NICMOS3 HgCdTe (256 x 256 pixels) made

by *Rockwell Int'l* for the J and K bands. The pixel scales are 1 arcsec and 3 arcsec in the I and J/K bands respectively. This camera will be attached at the cassegrain focus of the 1 metre telescope of the European Southern Observatory at La Silla, Chile. Survey operations will start in the first half of 1994. The sky will be divided into about 5500 slots spread over 3 zones of 30° extension in declination. Each slot represents a strip of 30° x 12′ on the sky that will be scanned in a step and stare mode. Each step represents 10′ in declination. The typical integration time on each position of the telescope is 10s. In these conditions, the expected performances are those indicated in Table 1 which summarizes a few other specifications of DENIS and 2MASS.

Table 1. Main specifications of DENIS and 2MASS

	DENIS	**2MASS**
Photometric bands	*I, J, short-K*	*J H short-K*
Pixel scales	1" (*I*), 3" (*JK*)	2" (*J H K*)
Sky coverage	southern sky	all-sky
Telescope	1^m ESO	dedicated 1.3^m
Array detectors	2 *NICMOS3* + 1 CCD *Tektronix*	3 *NICMOS3*
Expected K limiting magnitude(*point source*)	14 (3σ)	14.5 (3σ)
Scanning Mode	step & stare	continuous + special secondary
Operations schedule	1994-1997	1996-1998 (North)
Data processing centres	Leiden/Paris	IPAC

DENIS will be the first digitized survey of a hemisphere of the sky that will be implemented in real-time. It will lead to a considerable amount of data to handle and process, in real-time as well as off-line. The typical amount of data that will be processed and archived every night of observation will be about 6 to 8 Gbytes and the total amount of data after completion of the survey will be of the order of 4 Tbytes. Real-time data acquisition and processing (flat-fielding, sky subtraction, photometric and astrometric calibrations, source extraction) need a fast and powerful set of CPUs and peripherals. Each channel is equipped with a pair of 68040 Motorola processors and 4 Gbytes of disk storage capacity and a pair of Digital Audio Tape (DAT) units on which the raw data will be stored. An HP 9000/735 workstation will run a software package implemented by Dr. S. Kimeswenger (Innsbruck University), that will manage the overall data processing and the survey strategy and will be the only interface with the observer.

To process the data off-line, two dedicated data analysis centres (DAC) are currently under implementation at Leiden Observatory (under the responsibility of E. Deul) and at Paris Institut d'Astrophysique (under the management of J. Borsenberger). These centres are in charge of the final processing of the data and of preparing the databases and documents that will be eventually released to the wide community. The major task of these centres is to implement data processing hardware and software that will provide homogeneous documents. During the first months of operations, the DACs will also interact with the operations team in Chile, in order to fine tune the observing strategy parameters and to define the observing conditions (meteorological, seeing, instrumental characteristics, etc.) that will ensure the release of homogeneous products. They will implement the working databases (small and extended sources, history files, image database) and

the final catalogues (small and extended sources, asteroids, galaxies, atlases). A full recalibration of the survey is foreseen (after the completion of the survey).

4. Other Projects and Future Prospects

Apart from DENIS and 2MASS, other wide-field near infrared surveys are currently in progress or under design study. Their aim is rather to survey large, but limited areas of the sky in order to reach much fainter magnitudes than the all-sky surveys will do. Among them are the LITE project (Vigroux, this conference), the SPIREX project for a near infrared survey of 2.8 square degrees area down to $K = 23$, using a 2.5 metre telescope at the South Pole as part of the CARA project (Center for Astrophysical Research in Antarctica) (Hereld 1994).

A new direction that has been presented during this conference is the use of Schmidt telescopes with arrays of CCDs. In the near infrared range, pioneering work aimed at mapping large galaxies up to 2 μm is currently undertaken at the Kiso Schmidt telescope equipped with large (512 x 512) PtSi arrays (Ichikawa et al., this conference).

In the short term (2 to 3 years from now) even larger infrared arrays (InSb, HgCdTe) of 1024 x 1024 will be available with specifications comparable to those of the best CCDs. These powerful new tools will undoubtedly ensure a great future to wide field imaging in this spectral range.

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