Wide-Field Sky Surveys and Patrols

Infrared Wide-field Surveys

Wide-field sky surveys have proved to be essential tools for astronomical research: statistical astronomy, based on Schmidt photographic plate surveys, constitutes the keystone of accurate depictions of the stellar populations, and of the large scale structures in our Galaxy and in the Universe. Unfortunately, they have been long restricted to the optical spectral range, below 1 micron due to the limitation of the photographic plates. However, composite large scale images of the infrared sky obtained by space missions (IRAS or COBE), although limited by their low spatial resolution, recently led to major discoveries on large scale astronomical structures such as the galactic bulge, the infrared cirrus, the space distribution of nearby galaxies, the inhomogeneities of the cosmic background.

In the last decade, the technology of panoramic near infrared (1 to 10 μm) detector arrays has made such considerable progress in size and sensitivity that they are, today, comparable to the best optical CCD arrays. This technological breakthrough combined with the progress in computing power and rapidity allows us to achieve, now, with a 1 meter class ground based telescope and in a reasonable amount of time, complete digital sky surveys with an arcsecond resolution in the 1 to 2.2 micron bands (IJHK) down to the 14th magnitude at K. Several projects aimed at mapping large fractions of the sky or even the all sky, in this spectral range are now under way and should give rise to documents comparable to the Schmidt sky surveys before the end of this century. They will provide data sources that will lead to a complete renewal of star and galaxy counts and galactic structure research and to the investigations of unknown or poorly known stellar and galaxy populations.

Several ongoing projects of near IR surveys and, in particular, the European programme DENIS (Deep Near Infrared Southern Sky Survey) will be described and intercompared. Future prospects in this field will be briefly presented.

N. Epchtein
Observatoire de Paris
Departement de Recherche Spatiale
F-92195 Meudon Principal Cedex, France

A Telescope for Infrared and Submillimetre Ranges

The 300-millimetre telescope for infrared and submillimetre ranges was designed and produced at the Astronomical Observatory of the Nikolaev State Pedagogical Institute in collaboration with the Space Research Institute (Russian Academy of Science). This telescope is a model of the cooling infrared and submillimetre telescope, which was intended for mounting on the cosmic satellite as a component of the main optical-cryogenic system. This system is needed for astrophysical observations by the program 'Aelite'. The main purpose of this research is to receive the spectra and images of different objects and data on fluctuations of the background radiation in the infrared range (from 2 to 20 micrometer) and submillimetre range (from 100 micrometer to 2 millimetre).

Nikifor D. Kalinenkov, Igor M. Heyfets, Elena A. Panko, Sergei S. Guziy and Aleksei A. Shlyapnikov
Astronomical Observatory of Nikolaev State Pedagogical Institute
Roza Luxemburg, 24, Nikolaev, 327000 Ukraine

Gennediy B. Sholomitskiy
Space Researches Institute, Russian Academy of Sciences
Profsouznaya 84/32, Moscow 117296, Russia

Beijing — Arizona Colour (BAC) Sky Survey

A comprehensive spectral and temporal survey of 500 square degrees of the Northern sky will be carried out with the 0.6m f/3 Schmidt telescope + 2048 x 2048 Ford Aerospace CCD of the Beijing Astronomical Observatory. The spectral energy distributions of all objects to V = 21 in 500 separate fields will be measured from 3200 to 9000 angstrom with 17 narrow band filters of $\delta\lambda/\lambda = 0.05$. The variability of these objects will be sampled on time scales from minutes to about one year. Of the 500 fields, 150 are chosen centred on QSOs that cover the full range of known QSO properties; 150 are chosen on spiral galaxies 2′ - 5′ in diameter; 150 are chosen at random; and 50 are chosen for calibration purposes. This survey is specifically designed to:

a) find QSOs of all kinds with redshift that range from z = 1.7 to 6;
b) study the large-scale distribution of QSOs in the universe as a function of redshift;
c) determine the interrelationships among the structure, stellar populations and interstellar media of nearby spiral galaxies;
d) study the spatial distribution and spectral evolution of galaxies between the present day and a redshift of z = 0.2 - 0.3 (lookback time = 3 – 4 billion years); and
e) determine the large-scale topology of the universe.

Comparable numbers of stars will be found as extragalactic objects, out of which separate studies of Galactic structure will be derived. More detailed investigations of individual objects will be pursued with U.S.-based telescopes via spectroscopy and infrared imaging.

Jian-Sheng Chen
Beijing Astronomical Observatory
Chinese Academy of Sciences
Beijing 100080, P.R. China

CCD Imaging with a 1° Field

At most research telescopes the physical size of CCDs currently still restricts the accessible field-of-view. However, for galactic as well as extragalactic work a field significantly larger than the typical 15 arcmin is desirable to study objects with large angular extent. This is in particular desirable for objects that are well studied in other wavelength regimes such as the radio or FIR. High quality surface photometry of structures $\geq$ 30 arcmin can be obtained by using CCDs with telescopes of short focal lengths.

Here we present results from observations obtained with TI 800 x 800 CCDs (15 μm pixels) attached to 20 cm-aperture f/8 telescopes at Lowell Observatory, Flagstaff and Mt. Sinakas Observatory, Crete. This setup has $\approx$ 51 arcmin field-of-view at an image scale of 4 arcsec/pixel. The observations reported here were obtained with broad-band R filters.

We discuss surface photometry of NGC 3521 in comparison to recent HI data that show a declining rotation curve and present cut-off radii for the disks of several edge-on galaxies with large angular extent.

Ralf-Jürgen Dettmar
Space Telescope Science Institute
Baltimore, MD, USA
(affiliated to the Astrophysics Division in the Space Science Department of ESA)

Brian A. Skiff
Lowell Observatory, Flagstaff, AZ, USA

Kiriaki Xilouri
University of Heraklion, Crete

Wide-field CCD Imaging from the MIR Space Station

This paper reports the results of wide-field CCD observations from the MIR Space Station in the period 1988–1989. A brief description of the digital CCD camera ROZHEN as a technological experiment, consisting in the observations of stellar fields (M45-Pleiades, NGC 7000, M31, LMC etc.) and automatic control of astrophysical experiments within the frameworks of the second Bulgarian cosmonaut programme is given. The quality and possibilities of the wide band photometry of the wide angle observations in manned space flights and from board of space stations also are considered. In the framework of two subprogrammes, STANDARD and PHOTOMETRY, of the basic space flight science programme the well studied fields like M45, and M31 areas have been used in order to make an estimation of the photometric capabilities of the camera. The photometric accuracy and the limiting detectable magnitude of the camera are discussed. At 3-sigma level a surface brightness limit of 26.5 mag/arcsec^2 in V-filter has been achieved with an ordinary 50mm visual lens.

Peter Petrov and Christo Lukarsky
Space Research Institute, Bulgarian Academy of Sciences
Moskovska Str. 6, BG-1000 Sofia, Bulgaria

Valeri Golev
Chair of Astronomy, Faculty of Physics
Sofia University, James Boucher Blvd 5
BG-1126 Sofia, Bulgaria

MOUSE: a Mini Observatory for UV Space Exploration for a Wide-field Survey of the Poles and Equator of the Galaxy

This small orbiting observatory is described in its essential guidelines. Some insights in the optical solution (2 mirrors, 3 reflections telescope using pure hyperbolical surfaces, no aspherics) is given. An *in-flight* recentering of the photons collected by a solar-blind photon counter device will allow for an equivalent angular resolution of 2-3 arcsec, while the covered Field-of-View will exceed one square degree. The capabilities of the proposed spacecraft (along with low resolution grisms, polarizers and filters) are described. The choice of the projected covered sky (the two Galactic Poles, the Equatorial galactic Plane and some Bulge Windows) are described together with a detailed list of astrophysical scientific objectives addressable with such a flying telescope. The science comprises UV analysis of a complete sample of quasars, stellar population in galaxies, White Dwarfs, Globular and Open Clusters. Moreover a plan for the early UV detection of SuperNova events is described.

A. Bianchini, F. La Franca, S. Ortolani and P. Rafanelli
Department of Astronomy, University of Padova, Italy

L. Buson, E. Cappellaro, U. Munari, R. Ragazzoni and M. Turatto
Astronomical Observatory of Padova, Italy

M. Cecconi and I. Porro
Center of Studies and Activities for Space 'G. Colombo'
University of Padova, Italy

Relikt-HII: An All-Sky Survey in H(α)/H(β) Lines

Our group is preparing to carry out the 'Relikt-2' experiment (search for large-scale microwave background anisotropy). Within the framework of this experiment we are also planning to conduct independent measurements of the sky in H(α) and H(β) lines. The main scientific goals for this experiment are to study the large-scale distribution of extended HII emission. It enables us to separate cosmological signal and galactic free-free emission correctly. Besides, uniform all-sky measurements provide important information on the space distribution of HII regions in the Galaxy. In addition, a comparison between H(α) and H(β) maps can be useful in studying the galactic extinction, especially in combination with infrared data.

We are planning to equip the Relikt-2 spacecraft, which is scheduled to launch in 1995, with an optical spectrometer, operating in 4830–4880 Å and 6540–6590 Å wavelength ranges and having an angular resolution of 7 deg.

The main reasons for carrying out spaceborne experiments are:

- the absence of the atmosphere and consequent decrease in the brightness of the sky background and its instability;
- the absence of geocoronal lines;
- measurement sessions are independent of the seasons, 100% observational time;
- the possibilities of mapping the whole sky.

The instrument will be installed on board the Relikt-2 spacecraft (a modified version of the Prognoz spacecraft), which is planned to be placed into orbit at a distance of about $1.5e^6$ km from the Earth at the Lagrange point L2. The spacecraft rotates about its axis, directed toward the Sun, at approximately 3 deg per second. The instrument is so arranged that its optical axis is perpendicular to the rotation axis of the spacecraft. A constant orientation of spacecraft's rotation axis is maintained for about 7 days, which is sufficient to map a strip of 7 deg wide along the great circle of the celestial sphere. After that, the spacecraft's rotation axis is turned through 7 deg and a new series of measurements is made during the next 7 days. As a result, in half a year a complete map of the sky will be produced, and each area with a size of 7 x 7 deg will be observed approximately 1800 times. The spectrometer is expected to be operational for two years.

The optical spectrometer consists of an optics unit (a baffle, an objective, a slit, a diffraction grating and auxiliary optics), a detector system (a CCD array with a clock system and analog electronics; we are considering the possible use of an image-converted tube, mounted in front of the CCD array) and on-board computer.

I.A. Strukov, D.P. Skulatchev, I.A. Trifalenkov and A.A. Brukchanov
Space Research Institute, Moscow, Russia

Sonneberg Observatory: Sky Patrol, Field Patrol, the World's Largest Living WFPA — Purpose and Opportunities Past, Present and Future

This paper describes the Sonneberg Sky and Field Patrols, and outlines their origin and aims. These patrols have been the suppliers of the Sonneberg plate collection for 6 decades. Some 10,000 variable stars — among them illustrious objects such as HZ Her, FG Sge and BL Lac — were detected and investigated on this basis.

The collection of about 250,000 photographic plates still holds a wealth of unexploited optical information on the past history of astronomical sources. Currently use concentrates on investigation of and search for optical counterparts of X and Gamma-ray sources.

Over Sonneberg plans for the future — introduction of modern observational and photometric techniques, search for new, unforeseen events and systematic study of evolutionary effects — however, hangs the threat of closure like the sword of Damocles.

H.-J. Bräuer and G.A. Richter
Sonneberg Observatory, Germany

German Astrophysical Space Projects

The fundamental goal of the international astronomical community in space projects is the simultaneous use of telescopes in space for all different wavelength ranges, including cosmic ray research. For this endeavour international cooperation is mandatory. According to their knowledge and capability the German Space Agency, DARA, tries to participate in this challenging task.

After the successful launch of ROSAT and of CGRO Germany intends to take part in the ESA-missions: ISO, XMM, FIRST; the NASA-missions: ORFEUS-ASTROPAS on STS and AXAF; and the RKA-missions: SPECTRUM-X and RADIOASTRON. Other projects like: SOFIA, FUSE, SPECTRUM-UV and SIRFT are still under discussion.

Werner Klinkmann
DARA GMBH
Königswinterer Strasse 522-524
5300 Bonn 3, Germany

Very Wide-field Monitoring of the Sky

There is need for very wide-field monitoring of the sky in several branches of astronomy and astrophysics ranging from meteor research to monitoring of optical transients and counterparts to gamma ray burst sources. The photographic very wide-field monitoring of the sky is run at the Ondrejov Observatory and other stations of the Czech Meteor Network and is sensitive to record stars up to 11 mag on 3 – 4 h exposures or 1s flashes up to 3.0 mag over a field of view of 180 deg diameter. A CCD device for very wide-field monitoring is also in development with sensitivity of 5.0 mag for 1s flashes (and 10 mag for stars with 100s exposure) over a field of view of 50 x 60 degrees. Both systems will be briefly described and discussed.

R. Hudec and J. Soldan
Astronomical Institute
251 65 Ondrejov, Czech Republic

The Center for Analysis of Satellite Interference with Astronomy (CASIA)

An example is given of how CASIA is currently assisting astronomers with avoiding interference from artificial Earth satellites. Gamma-ray astronomers are eliminating many candidate optical counterparts from further consideration by readily identifying them as transient satellite phenomena. Another example details how, by computing ephemerides for the entire cataloged orbiting population in under an hour, CASIA can help surveys virtually eliminate satellite streaks from wide-field images.

Richard Rast
9516 Cargo Avenue Northeast
Albuquerque, NM 87109-6405, USA

The Schmidt Telescope at Calar Alto Observatory

The Max-Planck-Institut für Astronomie, Heidelberg, is operating an 80cm, f/3 Schmidt Telescope at the observatory on Calar Alto, southern Spain. Technical modifications of the telescope are described which have improved image quality and telescope handling: e.g. new plate holders, also for much less expensive 8 x 10 inch plates and films instead of 24 x 24 cm plates (5.5 x 5.5 degrees field size); a new and more stable mechanism for fixing the plate holders to the focal surface; autoguiders at the two guiding telescopes. Overall plate quality will be demonstrated by the astrometric precision achieved in determining e.g. cometary orbits.

K. Birkle, H. Bellemann and H. Elsaesser
Max-Planck-Institut für Astronomie
Koenigstuhl 17, W-69117 Heidelberg, Germany

Wide-field Imaging: 3-Mirror-Systems with High Light Gathering Power and a Wide Field

The desire of the astronomers for wide-field telescope systems which surpass the RCC (1:8 max 1.5 Grad) in light gathering power and field of view are relatively concrete today. For this type of telescopes detectors planned are CCDs in multichip arrangement.

3-mirror-telescopes permit fast focal ratios and large fields of view. Different optical systems are presented here with focal ratios up to 1:2.5 and wide fields up to 3.2 Grad with sectional drawing, aberration- and spot diagram.

The size of the fields requires a multichip arrangement of 2048 x 2048 pixel CCDs. The focal length of these systems is determined by the pixel size of 15 µm.

The linear field up to 400 mm, the spatial resolution and the aperture angle require some compromises. The optimal range for the focal length is from 6.25 to 10 m. Maximal resolution (1/3" per pixel) is attainable for a focal length of 8-10 m. Unfortunately, in this case the field is only 2 Grad. For fields of 3.2 Grad shorter focal lengths are necessary.

The aperture should be 2-3 m. It is determined by the attainable image quality and the focal ratio.

The calculations of the optical systems were carried out with optical design and analysis software developed by the author.

Telescope parameters investigated:

focal length	6.25 - 10 m
aperture	2 - 3 m
focal ratio	up to 1:2.5
image field	up to 3.2 Grad (for 400 mm linear field)
spectral range	365.01 nm - 706.52 nm (f dispersive effect for visible window of the CCD)

The systems investigated are:

- RRC-system with quartz-Gascoigne-plate and flattening lens
- RCC-system with Gascoigne-plate in reflection, 3-mirror variant
- 3-mirror systems with conic section and overdeformed mirrors.

Uwe Laux
Thüringer Landessternwarte Tautenburg
Karl-Schwarzschild-Observatorium
O-6901 Tautenburg, Germany

First Steps toward a CCD-based Sky Patrol

Considering the last living photographic sky patrols (e.g. at Sonneberg) on the one hand and the application of large CCDs to wide-field imaging on the other it seems to be necessary to discuss the establishing of a CCD-based sky patrol.

The poster sketches the scientific justification of a CCD-based sky patrol, mainly the:

- recording of new events like Novae, Supernovae, CV outbursts, comets and asteroids, and the
- monitoring of known objects like variables in general, AGNs and solar system objects.

We present an overview of the instrumentation needed which depends upon the projects for which the sky patrol is intended. Also, a proposal for an actual system is presented.

As a first step of testing large CCDs we give a report about the application of a Thomson chip (1300 x 1600 pixels) to sky patrolling and about the usage of ETC (Explosive Transient Camera) images for sky patrol purposes.

P. Kroll
Sonneberg Observatory, Germany

T. Lehmann
ESO, Garching, Germany