

EXPLORING THE COSMIC FRONTIER

Astrophysical Instruments for the 21st Century

Berlin, 18–21 May 2004

ABSTRACT BOOK

Talks

Seesion I: Future Astrophysical Facilities

Radio Facilities

R. Ekers

ATNF, Sydney, Australia

Five decades ago, astronomers finally broke free of the boundaries of light when a new science, radio astronomy, was born. This new way of 'seeing' rapidly uncovered a range of unexpected objects in the cosmos. This was our first view of the non-thermal universe, and our first unobscured view of the universe. In its short life, radio astronomy has had an unequalled record of discovery, including four Nobel prizes: Big-Bang radiation, neutron stars, aperture synthesis and gravitational radiation. New technologies now make it possible to construct new and upgraded radio wavelength arrays which will provide a powerful new generation of facilities. Radio telescopes such as the SKA together with the upgraded VLA will have orders of magnitude greater sensitivity than existing facilities. They will be able to study thermal and non-thermal emission from a wide range of astrophysical phenomena throughout the universe as well as greatly extending the range of unique science accessible at radio wavelengths.

Millimeter, submillimeter and far-infrared astronomy facilities

J. Cernicharo

IEM, Madrid

I will present the future observatories Herschel and ALMA and their capacities for the observation of the Universe in the wavelength range 60-3000 microns. From the solar system to the most distant galaxies, both instruments will allow to observe the cold gas and dust with an excellent frequency coverage and with very high angular resolution. Herschel will be particularly well equipped to study the water vapour emission/absorption in star forming regions and in circumstellar envelopes. I will discuss the complementarity of ALMA in studying water vapour at 183.31 and 325 GHz. In particular I will analyze the possibility to search with ALMA for H₂O emission at these frequencies in nearby galaxies, AGNs and ULIRGs (22 GHz H₂O megamaser galaxies). The capacity of Herschel and ALMA to study the chemical evolution of molecular clouds will be also presented. The possible synergy between both instruments in many scientific areas will be analyzed in this talk. I will also present some ground based facilities that are now operating at millimeter and submillimeter wavelengths and that will be operating during the early phases of the Herschel satellite and the ALMA interferometer.

High-Energy Astronomy Facilities

Guenther Hasinger

MPE Garching

The current generation of working high-energy observatories, in particular the NASA Great Observatory Chandra and the ESA Cornerstone mission XMM-Newton in the X-ray range and the ESA Gamma ray mission integral are providing exciting results covering all fields of astrophysics, but in particular about black holes, clusters of galaxies and the large scale structure of the cosmos, as well as the creation of the elements. Large X-ray facilities of the next decade are planned in global coordination: the X-ray Evolving Universe Spectroscopy mission (XEUS) by ESA/JAXA and the Constellation-X mission (NASA). Intermediate-size, specialised missions are prepared or planned in an international context. I will give an overview and discuss these missions. Plans for Gamma ray astronomy are discussed in an accompanying paper.

Future optical and near-infrared telescopes

R. Gilmozzi

ESO

I will briefly review the scientific drives for the next generation of ground and space optical-near infrared telescopes, and the synergy that they will create. I will report on the status of various projects, concentrating on the similarities and differences in the chosen technological solutions, and on the challenges that still lie ahead and what scope exists for collaboration in tackling them. Although I will try to be as complete as possible, I will describe in more detail the status of JWST, GSMT/CELT and OWL.

Gravitational wave astronomy

K. Danzmann

Max-Planck-Institute for Gravitational Physics (Albert-Einstein-Institute) and University of Hannover

Currently, several large laser-interferometric gravitational wave detectors (LIGO, VIRGO, GEO600, TAMA) are beginning to make observations in the audio frequency band from a few Hz to a few kHz. Experimental work for the LISA space-based detector to be launched in 2012 has commenced this year to open the low-frequency band from 0.1 mHz to 1 Hz. I will give an overview of status and prospects of this emerging field.

Session II: Cosmology and Fundamental Physics

Answering fundamental questions in physics with next-generation telescopes

S. Rawlings

Oxford Astrophysics

It is hard to imagine a more pressing question in physics than "what is the nature of the dominant form of energy in the Universe?" I will review the experiments made possible by next-generation telescopes which will allow the most stringent measurements of this dark energy. I will also review other experiments with the promise of telling us something radically new about the Universe, or the physics that describes it.

Fundamental physics with the SKA: Strong-field tests of gravity using pulsars and black holes

Michael Kramer

Jodrell Bank Observatory (University of Manchester)

The SKA will be unique in its capabilities in addressing some of the yet-unanswered questions in fundamental physics. One of the most fundamental questions remaining is whether Einstein's theory is the last word in our understanding of gravity or not. General relativity (GR) has to date passed all observational tests with flying colours. Solar system tests of GR are made under weak-field conditions, and even the existing binary pulsar tests only begin to approach the strong-field regime. As I will demonstrate in my talk, the SKA is capable of providing the important definite answers to fundamental questions such as: can GR correctly describe the ultra-strong field limit, are its predictions for black holes correct, and is the cosmos filled with a gravitational wave background? About 50 years after the discovery of pulsars marked the beginning of a new era in fundamental physics, pulsars observed with the SKA promise to transform our understanding of gravitational physics.

Constraining Variations in the Fundamental Constants with the SKA

S. J. Curran

University of New South Wales

Although presently controversial, some recent detailed studies of the relative positions of heavy element optical transitions and comparison with present day wavelengths suggest that the fine structure constant, $\alpha \equiv e^2/\hbar c$, may have evolved with time. Due to the different α -dependences of the Coulombic and magnetic moment interactions, comparison of atomic optical, HI 21-cm and molecular millimetre transitions can yield at least an order of magnitude in precision over the purely optical results. This, however, is severely limited by the low number of redshifted systems exhibiting HI and optical/rotational absorption currently known. Here we discuss how, with its unprecedented sensitivity and large tuning range, the Square Kilometre Array (SKA) is expected to significantly increase the number of known high redshift radio absorbers, thus greatly improving measurements of the variation in the fine structure constant and electron-to-proton mass ratio in the early Universe.

CMB polarization and early universe physics

J.L. Puget

Institut d'Astrophysique Spatiale, Orsay, France

The polarization of CMB anisotropies on large scale is one of the most powerful tool identified today to constrain the physics of the early universe. This is particularly true for inflation and the physics which could give rise to it. The presently planned experiments are limited by sensitivity when temperature anisotropies measurements will be limited only by fundamental limits when Planck flies. Future experiments for polarisation limited only by the ability to remove foregrounds are being studied and will be discussed.

Low to Medium Energy Gamma-Ray Astronomy: Status and Perspectives

Gottfried Kanbach

Max-Planck-Institut fuer extraterrestrische Physik, Garching

The fundamental cosmic processes of nucleosynthesis, radioactivity and acceleration of cosmic rays are based on two natural energy scales: the nuclear binding energy up to about 8 MeV and the rest mass of the electron. Low to medium energy gamma-ray astronomy offers therefore the most direct observational access to sites of steady and explosive nucleosynthesis, interstellar radioactive debris, and the acceleration of cosmic ray particles. We present a short summary of the current status of low energy gamma-ray astronomy. A severe deficiency of observational sensitivity in the MeV range exists, and will remain in the future, unless advanced instruments are developed. This 'sensitivity gap' will limit multiwavelength astrophysics not only in its attempts to bridge the wide interval between the mostly thermal hard X-ray range and the high energy non-thermal GeV/TeV bands, but also in the understanding of physics unique to the MeV range. We describe the present efforts to develop the next generation of instruments sensitive between several 100 keV and 10's of MeV and the plans for a future Advanced Compton Telescope project.

The evolution of the cosmic supernova rate

M. Della Valle¹, R. Gilmozzi², N. Panagia³, J. Bergeron⁴, P. Madau⁵, J. Spyromilio²,
P. Dierickx²

(1) – Arcetri-Firenze, (2) – ESO, (3) – ESA/STScI, (4) – IAP, (5) – UCSC

The detection and the study of high- z SNe is important for at least two reasons:

a) Their use as ‘calibrated’ standard candles in the local universe (both SNe-Ia and SNe-II) provides a direct measurement of H_0 whereas their detection at $z > 0.3$ allows to measure q_0 and to probe the different cosmological models;

b) The evolution of the cosmic SN rate provides a direct measurement of the cosmic star formation rate.

This talk will illustrate the impact that the use of an ELT can have on the latter issue.

SKA and the Magnetic Universe

Rainer Beck¹, Bryan Gaensler²

(1)- MPIfR Bonn, (2) - CfA Cambridge

The origin of magnetic fields is still an open problem in fundamental physics and astrophysics. Measurements of polarized radio synchrotron emission and Faraday rotation measures (RM) reveal three-dimensional maps of the strength, structure and turbulent properties of the magnetic field. The unique sensitivity and resolution of the Square Kilometer Array (SKA) will allow us to characterize the geometry and evolution of magnetic fields in galaxies, clusters and the IGM from high redshifts through to the present, to determine whether there is a connection between the formation of magnetic fields and the formation of structure in the early Universe, and to provide solid constraints on when and how the first magnetic fields in the Universe were generated.

Even the “empty” space may be magnetized, either by outflows from galaxies, by relic lobes of radio galaxies, or as part of the “cosmic web” structure. This intergalactic magnetic field plays an important role as the likely seed for field amplification in galaxies and clusters, and it may trace and regulate structure formation in the early Universe. The discovery of such a cosmic field is feasible with the SKA and would be a major step in understanding the Magnetic Universe.

Session III: High-redshift Universe, Galaxies, Galactic Evolution

The high redshift Universe and the formation and evolution of galaxies

Simon Lilly

ETHZ, Geneva

Our ability to observe the Universe at substantial look-back times and thereby directly observe the formation and evolution of galaxies and other large structures is a rather profound one. The resulting increase in humanity's "horizons" in space and time over the last 20-30 years may rank with many of the great revolutions in science. I will attempt to review what we know and especially what we do not know about the galaxy population at high redshift, focussing on those open questions that could plausibly be answered with the broad suite of new facilities that are now planned.

Frontier Science Enabled by a Giant Segmented Mirror Telescope

R.P. Kudritzki

Institute for Astronomy, University of Hawaii

The unique challenge of astronomy in the 21st century is to study the "evolution of the universe in order to relate causally the physical conditions during the Big bang to the development of RNA and DNA" (Riccardo Giacconi, 2002 Nobel Prize in Physics). A 20m to 30m telescope will provide capability to meet this challenge. It will, for the first time, permit observations of hundreds of extra-solar giant planets, the disks from which planetary systems take form, the building blocks of galaxies and the process of galaxy assembly, the early evolution of chemical elements heavier than helium, and the emergence of large scale structure as mapped by galaxies and intergalactic gas during the first billion years following the Big Bang. This paper gives a summary of the work done by the GSMT Science Working Group (SWG). The SWG was formed in July 2002 by NOAO following a suggestion by the NSF Division of Astronomical Sciences. The primary focus of the SWG, so far, has been the discussion the forefront astrophysical problems likely to emerge over the next decade, the science potentially enabled by next generation telescopes, design options that can achieve that potential, and technologies that must be advanced or developed in order to realize viable telescopes at acceptable costs.

Overview of the Science Case for a 50-100m Extremely Large Telescope

Isobel Hook

University of Oxford

We present an overview of the science case for a ground-based 50-100m Extremely Large Telescope. This was the subject of an OPTICON-sponsored meeting in Marseilles, France in November 2003. Four key scientific themes were identified by the participants: Terrestrial planets in extra-solar systems; Stellar populations across the Universe; Building galaxies since the darkest ages; The first objects and re-ionisation structure of the Universe. Although by no means an exhaustive list of science areas in which ELT will have a great impact, these cases provide examples where an ELT can make a dramatic advance in our understanding of the Universe around us. Here we describe these and other science themes and the challenging demands they place on ELT performance. See <http://www-astro.physics.ox.ac.uk/imh/ELT/> for more information, including the full list of participants in this work.

Probing the Growth and Evolution of Galaxies with the ELT

Matthew D. Lehnert

MPE-Garching

One of the major goals of astrophysics is to map the distribution and growth of both the baryonic and dark matter components of galaxies at moderate to high redshift ($z=1-5$). I discuss how this can be accomplished with the ELT by mapping out the spatially resolved kinematics, star-formation, and chemical abundances of galaxies as well as measuring the kinematics of satellite objects – both their internal kinematics and their velocity relative to the most massive component. Direct measurements of the evolution of the mass, angular momentum, and star-formation history of galaxies as a function of galaxy radius and epoch will provide critical constraints on our understanding of galaxy evolution.

New Experimental Possibilities and New Problems in CMB Research and Observations of Clusters of Galaxies

R. Sunyaev

Max Planck Institute for Astrophysics, Garching, Germany

The tremendous increase in the sensitivity of microwave and X-ray bolometers of the Planck Surveyor spacecraft, Atacama Cosmology, APEX, and South Pole telescopes and ASTRO-E2 X-Ray Observatory permits theoreticians to think about completely new ways to study chemical evolution and the ionization history of our universe. These instruments under construction will permit us to measure peculiar velocities of clusters of galaxies and to investigate the internal motion and nature of turbulence in clusters of galaxies.

Observations of the first galaxies: lessons learned for future ground based large telescopes

M. Bremer¹, J. Bergeron², M. Lehnert³, I. Hook⁴

(1) – Bristol University, (2) – Institute d’Astrophysique de Paris, (3) – MPE, Garching, (4) – Oxford University

We will review observations of the highest redshift galaxies, quasars, GRBs and SNe in the context of the capabilities of future ground-based large telescopes. I will discuss which observations are better carried out from space and how the properties and evolution of these objects drive instrumentation choices for any future large telescopes.

The High Redshift Universe as Seen by the Allen Telescope Array

Geoffrey C. Bower

UC Berkeley

The ATA is a new radio telescope operating at cm wavelengths. Its wide field of view and continuous frequency coverage make it an excellent instrument for surveys of both continuum and line sources. I will discuss in detail two goals of the ATA: an HI counterpart to the Sloan Digital Sky Survey; and surveys for transient sources.

Session IV: AGN, Compact Objects

AGN studies on the crossroads of astrophysics

J.A. Zensus, A.P. Lobanov

Max-Planck-Institut für Radioastronomie

Over the last five decades, AGN studies have produced a number of spectacular examples of synergies and multifaceted approaches in astrophysics. The field of AGN research now spans the entire spectral range and covers more than twelve orders of magnitude in the spatial and temporal domains. The next generation of astrophysical facilities will open up new possibilities for AGN studies, especially in the areas of high-resolution and high-fidelity imaging and spectroscopy of nuclear regions in the X-ray, optical, and radio bands. These studies will address in detail a number of critical issues in AGN research such as processes in the immediate vicinity of supermassive black holes, physical conditions of broad-line and narrow-line regions, formation and evolution of accretion disks and relativistic outflows, and the connection between nuclear activity and galaxy evolution. These aspects of future AGN studies will be discussed in this review.

New Frontiers in AGN Physics - The X-ray Perspective

Th. Boller

MPE Garching

After 4 years of dedicated service from the new generation of X-ray telescopes, XMM-Newton and Chandra, we are at the point to generalize the AGN physics deduced from numerous individual observations. The talk will review the basic open questions posed by earlier X-ray missions which have now been answered as well as new questions which still require further investigation. The topics critically discussed will include: the physics of the innermost region of AGN, the starburst-AGN connection, new aspects of the Seyfert unification, new insights into the galaxy interaction processes, supermassive and stellar-mass black hole analogies, the chemical composition and its implications for cosmology.

Deep Radio Surveys and the SKA

K. I. Kellermann

NRAO

The VLA has been used to survey the HDFN, the CDFS, and SA13 down to rms noise levels as low as 2 microJy. These surveys, which complement the wealth of optical, IR, and X-ray data which cover these fields, indicate that although the radio emission at microJy levels is increasingly due to star forming activity, an AGN component is not uncommon. We discuss the implications of the VLA surveys for the even deeper surveys which will be possible with the SKA including the effects of confusion which may limit the performance of the SKA unless very long baselines, up to thousands of kilometers are used. Even then, VLA and MERLIN observations indicate that the typical angular size of microJy sources is about an arcsecond. If this persists at nanoJy levels, the SKA may be limited by natural confusion, independent of its angular resolution.

Space-borne radio astronomy in the era of LOFAR, ALMA and SKA

L.I.Gurvits¹, H.Hirabayashi²

1 – JIVE, Dwingeloo, The Netherlands; 2 – ISAS, Sagamihara, Japan

LOFAR, ALMA and SKA will open up new ranges in sensitivity, frequency coverage, spectral and temporal resolution of radio astronomy studies. Angular resolution of these new radio telescopes will be defined by their sizes, ultimately limited by the size of Earth. Radical sharpening of the “radio view” at the Universe can be achieved by extending apertures (baselines) of radio astronomy facilities beyond the planetary scale. We analyze possible orbital extensions of Earth-based radio telescopes using the first dedicated Space VLBI mission VSOP as a benchmark. We begin from a brief review of scientific tasks which require angular resolution higher than routinely available at present. We also consider possible technical implementation of space-borne radio telescopes at various frequency domains. As a conclusion of our analysis we underline scientific and technological components of the three major Earth-based radio astronomy facilities which should be seen as bridges to their future orbital extensions.

eVLBI: A Wide-field, Imaging instrument with Milliarcsecond Resolution and MicroJy Sensitivity

M.A. Garrett¹, J.W. Wrobel², R. Morganti³

(1) - JIVE, (2) - NRAO, (3) - ASTRON

Over the last 18 months, significant progress has been made in connecting together the largest radio telescopes in Europe via optical fibres. This technique, known as eVLBI, promises to transform VLBI into a real-time instrument, dramatically improving the reliability, flexibility and performance of current arrays, such as the European VLBI Network (EVN). In this presentation we review current progress in this area and consider future (short-term) developments. We also look forward to the scientific return of eVLBI, focussing in this presentation, on eVLBI’s contribution to deep field studies of faint and cosmologically distant extragalactic radio sources. In addition, to unravelling the nature of these distant systems, eVLBI can provide milliarcsecond astrometric precision to ensure accurate multi-wavelength image registration.

Results from observations of AGNs with the H.E.S.S. telescope system and Future plans

Michael Punch for the H.E.S.S. collaboration

PCC/APC, Collège de France

The H.E.S.S. (High Energy Stereoscopic System) phase I is comprised of four Imaging Atmospheric Cherenkov telescopes, for observation of galactic and cosmic sources of very high energy gamma rays. Its installation in the Khomas highlands, Namibia has been completed in December, 2003. The first of these telescopes was installed in June 2003, and data-taking has proceeded since that time. The HESS telescope system provides a significant improvement in sensitivity and a threshold for detection below that of previous Imaging Atmospheric Cherenkov Telescopes. The characteristics for the phase-I will be presented, together with plans for phase-II of the experiment, comprised of a large telescope in the centre of the current phase-I providing a lowered threshold and increased sensitivity. We can observe AGNs up to redshift 0.5 with HESS and 2-3 with HESS Phase-2, which provides a unique capability for study of spectral and temporal characteristics on timescales of several hours or even less than 1 h (depending on the strength of flares). We will present the first results from a number of southern AGN observed during the installation of the phase-I, in particular concerning the detection and spectral properties of the AGN PKS2155–305.

The dust and gas content of quasars in the early universe

Pierre Cox¹, F. Bertoldi², C.L. Carilli³, A. Omont⁴, A. Beelen¹, F. Walter³, & K.M. Menten²

1 – Institut d’Astrophysique Spatiale, Orsay, France; 2 – Max-Planck-Institut für Radioastronomie, Bonn, Germany; 3 – NRAO, Socorro, USA; 4 – IAP, Paris, France

Direct observations of millimeter and submillimeter emission from high-redshift quasars and galaxies are amongst the most recent to be applied to the study of galaxy evolution. They have opened a new window in our understanding of the nature of these gas- and dust-rich massive, luminous systems. We will summarize results from recent surveys done at millimeter wavelengths of about 150 high redshift ($1.5 < z < 6.4$) optically luminous QSOs. The redshifted thermal dust infrared emission of about one third of them have been detected, with implied dust masses of a few 10^8 solar masses and far-infrared luminosities in between 10^{12} and 10^{13} solar luminosities. Measurements of the radio continuum and the CO line emission provide evidence that a substantial fraction of the far-infrared emission of these high- z quasars must be caused by star formation. The fact that at high redshift, optically bright quasars appear to be associated with major starbursts provide direct evidence that vigorous star formation is co-eval with the rapid growth of massive black holes at the earliest epochs of the Universe. Finally, the prospects in the study of the early Universe that will be possible with the next generation of instruments under development, most notably with the Atacama Large Millimeter Array will be described.

Session V: ISM, Stars, Star Formation

Physics of Star Formation

Th. Henning

Max Planck Institute for Astronomy, Heidelberg, Germany

The birth of stars is one of the most fundamental processes in astrophysics, shaping the structure of galaxies and leading to the formation of planetary systems. The talk will summarize our present knowledge of the physics of star formation and will discuss key open issues. It will demonstrate how new technologies and facilities such as adaptive optics, ALMA and JWST will provide new insights in the star formation process.

The Physics and Chemistry of High Mass Star Forming Regions

Tom Wilson

ESO, Garching

High mass stars have a disproportionate effect on the interstellar medium since they produce heavy elements and inject turbulence into their surroundings. These stars end their lives as supernovae or black holes. Thus, the formation of massive stars is of great importance for the development of our galaxy and also the early universe. The study of massive star formation is at an early phase since these seem to form in groups and to involve external pressure. This presentation will review the chemistry and structure of high mass star forming regions and indicate how ALMA will provide significant progress in this area.

Synergy of millimeter and infrared observations of star- and planet-forming regions

Ewine F. van Dishoeck

Leiden Observatory

The earliest stages of star- and planet formation are obscured by tens to hundreds of magnitudes of extinction. Observations of the gas and dust at long wavelengths often provide the only way to obtain information on the physical and chemical processes that occur deep inside the clouds. In this talk, the synergy of millimeter and infrared observations of molecules and dust features will be emphasized and their diagnostic values summarized. A few illustrative examples of recent studies using the VLT, Spitzer, JCMT and OVRO on protostellar regions and circumstellar disks will be presented.

GAIA: Galactic Astrophysics by Imaging and Astrometry

G. Gilmore

Institute of Astronomy, Cambridge University

GAIA is a major ESA mission, currently under construction for launch no later than 2012, which will revolutionise knowledge of the contents, formation, history, Dark Matter distribution and content, and structure of the Galaxy and the Local Group; and make major contributions to all of astronomy, from Cosmology to the Solar System. GAIA will provide a complete census at 0.1arcsec spatial resolution in several passbands of the sky brighter than $V=20.5$, with over 100 observations per object during the 5+-year mission. Astrometry with precision of 10microarcsecs will be delivered for the 300million stars brighter than $V=15$, and with precision better than 1milliarcsec for the one billion objects brighter than $V=20$. Corresponding distances will provide exquisite calibration of 3-D structure, the distance scale, and the 3-d mass distribution in the Local group. cf <http://www.rssd.esa.int/Gaia/>

Large-Scale Surveys with the ALFA Focal Plane Array at Arecibo

Paul F. Goldsmith

Department of Astronomy and National Astronomy & Ionosphere Center, Cornell University

The 305m Arecibo radio telescope remains the largest filled-aperture telescope in the world. Its unequalled sensitivity is now being dramatically enhanced for large-scale surveys by the installation of ALFA, the Arecibo L-band Focal Plane Array. This is a 7 pixel, dual-polarization system covering 1225 to 1525 MHz. The expected system temperatures will be just over 20 K and the antenna-feed sensitivity in the range 8 to 11 K/Jy. These numbers indicate that large-scale surveys will have a profound effect on our understanding of several different areas of astronomical research. The primary research areas for ALFA include (1) pulsars; (2) extragalactic HI; (3) Galactic HI; (4) Galactic continuum; and (5) Galactic recombination lines. For pulsars, low-lattitude and high-lattitude surveys are envisioned which should detect on the order of 1000 new pulsars, possibly including objects in exotic combinations and having high spin rate. Large-area moderate and smaller-area deep extragalactic surveys in HI are being planned, as are searches for OH megamasers. Galactic HI, including studies of the plane, high velocity clouds, and self-absorption, will all be covered in various programs. Three different spectroscopic systems are being constructed to satisfy the requirements of these different surveys, which will be described in detail along with the organization of survey consortia and membership guidelines.

Preliminary Science Results from the Submillimeter Array

Alison Peck and the SMA teams at SAO and ASIAA

Harvard-Smithsonian CfA

The Submillimeter Array (SMA) is nearing completion on the summit of Mauna Kea and has begun science operations. The completed instrument will consist of eight 6-m diameter elements in reconfigurable arrays providing baselines from 7 to 500 m and resolutions of about 0.1 to 5 arcseconds. The full array will cover the atmospheric windows around 230, 345, 460, 650 and 850 GHz (1.3 to 0.3 millimeter wavelength) with a total bandwidth of 2 GHz and high spectral resolution. The dedication took place in November 2003, and internal science proposals have been accepted for the 230 and 345 GHz receivers since that time. We will report on exciting results that are becoming available as data using the 230 GHz and 345 GHz receivers during the commissioning phase of operations are reduced. The science topics explored with these early observations range from star formation and evolved stars in our Galaxy to imaging starburst regions in nearby galaxies and attempting to perform high precision astrometry on extremely high redshift submm galaxies. In addition, phase closure at 682 GHz and 691 GHz was achieved in late 2002 using 3 antennas, and preliminary results of science observations at these frequencies will be reported.

Acknowledgement: The SMA is a collaborative project of the Smithsonian Astrophysical Observatory and the Academia Sinica Institute of Astronomy & Astrophysics of Taiwan.

The network for ultraviolet astrophysics (NUVA) and the future of UV astronomy in Europe

Ana I Gomez de Castro

Instituto de Astronomia y Geodesia (CSIC-UCM)

The UV range supplies a richness of experimental data which is unmatched by any other domain for the study of hot plasma with temperatures between 10^4 K and 10^5 K; the resonance lines of the most abundant species in the Universe are observed in the UV. Plasma at these temperatures is observed in all astrophysical environments extending over hot stars, cool stars and planetary atmospheres, gaseous nebulae, the warm and hot component of the ISM, circumstellar material, the close environment of black holes of all masses from X-rays Binaries to Nuclei of Galaxies, accretion disks, and the intergalactic medium. In addition, the electronic transitions of the most abundant molecules, such as H_2 , are observed in this range which is also the most sensitive to the presence of large molecules such as the PAHs. The Network for Ultraviolet Astrophysics (NUVA) has been established within the OPTical and Infrared COordination Network for Astronomy (OPTICON), which is financed by the European via the Framework VI program. This network has been defined within the OPTICON activities related to the identification of needs and development of actions to structure the European astronomical community around several large projects. The objectives of the NUVA are to formulate and operate a UV astronomy network and to plan and execute a road mapping exercise for the future of the UV astronomy in Europe.

Session VI: Planets, Origins of Life

Detection and Characterization of Extra-Solar Planets

M.A.C. Perryman

ESA-ESTEC, Noordwijk, The Netherlands

Various techniques are being used to search for extra-solar planetary signatures, including accurate measurement of positional (astrometric) displacements, gravitational microlensing, and photometric transits. Planned space experiments promise a huge increase in the detections and statistical knowledge arising from transit and astrometric measurements. In contrast, imaging of even nearby Earth-mass planets in the habitable zone and the measurement of their spectral characteristics, typified by the TPF and Darwin missions, represents an enormous challenge. A number of proposed precursors aimed at exploiting coronagraphy or occultations are being studied. Beyond TPF/Darwin, Life Finder would aim to produce confirmatory evidence of the presence of life, while an Earth 'imager', some massive interferometric array providing resolved images of a distant Earth, appears only as a distant vision. A 10 nas astrometric mission would detect 'Earths' systematically out to 100 pc.

Down to earths, with OWL

O.R. Hainaut, R. Gilmozzi

European Southern Observatory

Realistic extra-solar systems simulations have been observed using realistic models of ELTs ranging from 30m to 140m. The atmospheric characteristics are taken into account (turbulence parameters and distribution), as well the details of the optical layout of the segmented mirrors of ESO's OWL and their effects on the telescope's point spread function. We consider various stages of active optics correction, ranging from none (which already gives a larger than usual Strehl ratio due to the fact that the mirror is much larger than the seeing scale length) to optimal, 3rd generation "extreme" active optics. Nevertheless, we will focus on AO technology that constitute only a realistic/moderate extrapolation of what is available today. Using these simulations, we will quantify the advantages of having a 100m-class telescope over a 30m, both in terms of number of observable host-star candidates, time needed to observe them, and scientific output for each observed planet. In particular, we will discuss the expected results for the usual "hot Jupiters", but also demonstrate that significant information can be obtained for Earth-like planets.

Astrometric detection of extrasolar planets

J.C. Guirado, E. Ros, et al.

University of Valencia, MPIfR, et al.

The increasing population of extrasolar planets, found mostly from radial velocity surveys, indicates that the presence of planets around stars is a common phenomenon. Although spectroscopic techniques have shown to be an excellent tool for planet discovery, high-precision astrometry presents significant advantages and it appears as the preferred technique to explore regions of the orbital parameter space inaccessible by Doppler measurements. At optical wavelengths, detection of extrasolar planets figures in the science goals of a number of future space-based instruments, SIM and GAIA, designed to provide micro-arcsecond precise narrow-angle astrometry of nearby stars. At radio wavelengths, SKA will provide both the sensitivity and the astrometric precision needed over a survey of stars to contribute significantly to the planetary search. Combination of all techniques at all possible wavelengths is essential to optimize the scientific outcome. As an excellent example of complementarity of different techniques/wavelengths, we will revisit the case of the detection of the unseen companion to AB Doradus.

The CHEOPS Project: CHaracterizing Exo-planets by Opto-infrared Polarimetry and Spectroscopy

Markus Feldt¹, Th. Henning¹, S. Hippler¹, M. Turatto², R. Neuhauser³, M. Schmid⁴,
R. Waters⁵

(1) – MPIA Heidelberg, (2) – Osservatorio di Padova, (3) – AIU Jena, (4) – ETH Zurich, (5) –
University of Amsterdam

We are currently investigating the possibilities for a high-contrast, adaptive optics assisted instrument to be placed as a 2nd-generation instrument on ESO's VLT. This instrument will consist of an "extreme-ao" system capable of producing very high Strehl ratios, a contrast-enhancing device and an integral-field spectroscopic detection system. It will be designed directly take images of sub-stellar companions of nearby (≤ 100 pc) stars. We will present our current design study for such an instrument and discuss the various ways to tell stellar from companion photons. Results of our latest simulations regarding the instrument will be presented and the expected performance discussed. Derived from the simulated performance we will also give details about the expected science impact of the planet finder. This will comprise the chances of finding different types of exo-planets, the scientific return of such detections and follow-up examinations, as well as other topics like star-formation, debris disks, and planetary nebulae.

Posters

I. Future Astrophysical Facilities

I(a) Radio astronomy

1

The new 40-m radiotelescope of OAN in Yebes (Spain)

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The National Astronomical Observatory of Spain (OAN) is concluding the construction of a new 40 meter radiotelescope in Yebes (80 km away from Madrid, Spain). This instrument will be the most important large scale facility for radioastronomy at a national level, and will become an important partner in the VLBI networks at centimeter and millimeter wavelengths. The 40 meter radiotelescope will operate in several bands from 13 cm (2.3 GHz) to 2.6 mm (115 GHz), both as a single antenna and as one element in a VLBI array for astronomical and geodetic studies. The antenna consists of a homologous parabollic reflector, and a subreflector on a quadrupode, in Nasmyth focus configuration. This system is installed on a concrete pedestal which serves also as control building and workshop. The large receiver cabin will move in azimuth together with the telescope. All receivers will be located in the secondary focus cabin (so that several of them can be used simultaneously). A receiver for holography will operate in primary focus configuration. Commissioning and observations could start at the end of 2004.

2

HIFAR - Cosmology with an ultra-wide-field radio telescope

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(1) CSIRO Australia Telescope National Facility, (2) CSIRO ICT Centre, (3) University of Sydney

We present a design for a large radio telescope, HIFAR, which has a field of view of up to 100 deg² and could be built at moderate cost by 2010 either as an upgrade to the Low-Frequency Array (LOFAR) or as an advanced prototype or 'pathfinder' for the Square Kilometre Array (SKA). In one year, such a telescope would be able to measure HI redshifts for up to 3 million galaxies at redshift $z \sim 1$ or 7 million galaxies at $z \sim 0.5$. HIFAR can therefore provide a extremely powerful test of cosmological models involving dark energy, as well as enabling new studies of galaxy evolution, pulsars and AGN.

3

The Allen Telescope Array

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(cancelled)

4

Design of Near-term Next Generation Space-VLBI Mission VSOP-2

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Successful launch in 1997 and operation of space-VLBI satellite HALCA and VSOP(VLBI Space Observatory Programme) observations with wide international collaborations made space-VLBI a reality. Second generation space VLBI mission, VSOP-2, has been planned. This is a near term project with the launch date of about 2010 or so. Scientific objectives are very high angular resolution imaging of astrophysically exotic regions, which includes the jets, accretion disks of active galactic nuclei(AGN), water maser emissions, micro-quasars, corona of young stellar objects, etc. The satellite orbit is 25,000 km apogee height and 1,000 km perigee height with 31 degrees inclination angle, and M-V rocket is assumed as a launcher. The highest angular resolution of about 40 micro-arc-second is achieved at 43 GHz band. Engineering developments are in progress to realize this mission, and those items are deployable antenna, high data rate transmission, cryogenic receivers, antenna pointing, accurate orbit determination, etc. The mission satellite is planned to have a 9m deployable mesh antenna with 8, 22 and 43 GHz receivers, and a high speed data down link at 1 Gbps to the ground tracking stations to be recorded in VLBI format. International collaboration is important as for VSOP, and both instrumental and scientific collaborations are under discussion.

5

Imaging across the spectrum: Synergies between SKA and other future telescopes

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The Square Kilometer Array (SKA) would become operational at the time when several new large optical (LBT, CELT, EURO50, OWL) X-ray (CONSTELLATION-X, XEUS, MAXIM) and Gamma-ray (GLAST) telescopes are expected to be working. The main drive for building the SKA is a significant improvement of sensitivity that would widen the general scope of the centimeter-wavelength radio science and connect better the radio science with astrophysical studies made in other bands of electromagnetic spectrum. In the past two decades, radio astronomical instruments have typically featured a superior resolution and adequate imaging performance, compared to the instruments working in other spectral bands. The future optical telescopes like CELT and OWL would both surpass the dynamic range offered by the VLA and match the resolution of ground-based centimeter wavelength VLBI. This is a compelling argument for designing the SKA such that it offers similar imaging capabilities. Imaging capabilities the SKA are compared here with those of the major future telescopes.

6

TO THE CONCEPTION OF SOLAR RADIOTELESCOPES FOR THE 21st CENTURY

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(cancelled)

7

Construction of the Korean VLBI Network (KVN)

B.W. Sohn for the Korean VLBI Network team

Korean Astronomy Observatory

The new Korean VLBI project started in 2001, as a 7 year project which is fully funded by Korean government. We plan to build 3 new high-precision radio telescopes of 20-m diameter in 3 places in Korea, which will be used for VLBI observations exclusively. The 2/8, 22, 43, 86, 100, and 150 GHz HEMT receivers will be installed for astronomical, geodetic, and earth science VLBI research. The three lower frequency band receivers will be installed first to test the system and to initiate VLBI experiments, but millimeter-wave VLBI will ultimately be the main goal/focus of KVN. For the front-ends, we are going to install a multi-channel receiver system which employs perforated plate filters within a quasi-optical beam transportation system. This receiver system will give reliable phase calibrations for mm-VLBI as well as enable simultaneous multi-frequency band observations. We have completed the design of the KVN DAS system of 2 Gbps sampling rate, which will use 4 data streams to meet the multi-channel requirement. The hard-disk type new Mk 5 will be used as the main recorder of KVN. We plan to develop a new correlator for KVN, but this is still in the planning phase. We anticipate for diverse scientific and technical collaborations with leading institutes in VLBI, which will be essential for the success of our project. After the completion of KVN, we will be actively involved in international VLBI programs.

8

Frequency protection for 21st century instruments

Wim van Driel

Observatoire de Paris/IUCAF

For a fruitful return of the large financial investment foreseen in 21st century astrophysical instruments, these will need to be able to operate in an electromagnetic environment full of increasing man-made interference, driven by commercial pressure. Key scientific goals require very sensitive observations outside the frequency bands allocated for use by radio astronomy for example for highly redshifted spectral lines. Besides the development of technical methods for the suppression of unwanted interference, concerted efforts are being made to define specific regulatory protection measures for ALMA and the SKA at the International Telecommunication Union, who regulates the worldwide spectrum use. These efforts are being led by astronomers from IUCAF, the Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science of ICSU. Furthermore, they participate in exploratory ITU regulatory studies on the protection of radio astronomy from space and on the protection of ground-based optical observations.

I(b) Millimeter, submillimeter and far-IR astronomy

9

SCUBA-2: A large-format CCD-Style Imager for Submillimetre Astronomy

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We describe the capabilities of SCUBA-2, the first CCD-like imager for submillimeter astronomy, and the technologies that make it possible. Unlike previous detectors using discrete bolometers, SCUBA-2 has two dc-coupled, monolithic arrays with a total of $\sim 10,000$ bolometers. SCUBA-2's absorber-coupled pixels use superconducting transition edge sensors operating at ~ 120 mK for photon-noise limited performance and a SQUID time-domain multiplexer for readout. It will offer simultaneous imaging of an 8×8 arcmin field of view at wavelengths of 850 and 450 μm . SCUBA-2 is expected to have a huge impact on the study of galaxy formation and evolution in the early Universe as well as star and planet formation in our own Galaxy. Mapping the sky to the same S/N up to 1000 times faster than SCUBA, SCUBA-2 will also act as a pathfinder for submillimeter interferometers such as ALMA. SCUBA-2 will begin operation on the JCMT in 2006.

10

The Large Millimeter Telescope

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The LMT is a 50m-diameter millimeter-wave antenna designed for best performance in the 1-4mm band. The telescope is being built in a collaboration between the University of Massachusetts at Amherst (UMass) in the USA and the Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE) in Mexico. Construction is well under way at Volcan Sierra Negra in the state of Puebla, Mexico, approximately 100 km east of the city of Puebla. Erection is expected to be completed by the end of 2004, with outfitting running through 2005 and first light being planned in 2006. The LMT will have nearly 2000 m² of collecting area with an overall surface accuracy of 70 micron rms. Its sensitivity will exceed that of existing millimeter-wavelength telescopes by a significant margin. As a completely filled aperture, the LMT will have the optimum sensitivity to low surface brightness emission at an angular resolution of 6-12 arcsec, which is comparable to that of the maps presently made with today's interferometric arrays. Consequently, we expect the LMT to become one of the premier instruments to explore the cosmic frontier.

11

An Overview of the Submillimeter Array Telescope

Alison Peck and the SMA teams at SAO and ASIAA

Harvard-Smithsonian CfA

The Submillimeter Array (SMA) is a new interferometer dedicated to observations in mm and sub-mm wavelengths located on Mauna Kea, near the CSO and JCMT facilities. The array consists of eight 6-meter diameter antennas arranged loosely on the sides of Reuleaux triangles. Four configurations will soon be available with maximum baseline lengths of approximately 24, 64, 171 and 470 meters, respectively. Each antenna is equipped with a cryostat at its Nasmyth focus and will accept eight receivers covering all useable bands from 230 to 850 GHz. At present (March 2004) all antennas have receivers at 230 and 345 GHz, and 6 of the 8 have receivers at 690 GHz. The maximum angular resolution will vary from 0.4 to 0.1 " over the frequency range. Signal processing is performed on a special purpose XF correlator, which is based on a chip developed at the Haystack Observatory and the NASA/SERC for VLSI Design. The correlator will accept two channels from each antenna of 2 GHz bandwidth in each sideband, making possible either dual polarization or simultaneous dual frequency operation. The antennas have reflector backup structures constructed of carbon fiber tubes and steel nodes. Each primary reflector consists of 72 machined aluminum panels, which have rms accuracies of about 5 microns. The overall reflector surfaces have an rms accuracy of 12-25 microns. A pilot program for combined observations with the CSO and JCMT is planned for 2005.

Acknowledgement: The SMA is a collaborative project of the Smithsonian Astrophysical Observatory and the Academia Sinica Institute of Astronomy & Astrophysics of Taiwan.

12

Tunable Heterodyne Receivers - A Promising Outlook for Future Mid-IR Interferometry

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Providing high spectral resolution and sensitivity, heterodyne receivers are well established detectors for mid-infrared spectroscopy. However, being based on fixed frequency CO₂ lasers as local oscillators, most systems are currently restricted to observations at the frequencies of the available laser lines. This major limitation can be overcome by using tunable diode lasers (TDL), which operate at wavelengths from 3 to 30 μ m. The I. Physikalisches Institut of the University of Cologne has successfully built such a system and demonstrated its performance at several astronomical telescopes. Especially at large scale interferometers like the VLTI heterodyne receivers offer additional advantages. Inherent to the heterodyne principle the signal correlation of the individual telescopes is done at radio frequencies. This is a standard technique since many years and technically much easier than optical correlation. Furthermore, the signal is amplified prior to detection, so that there is no additional noise arising from the correlation.

I(c) Near-IR and optical astronomy

13

Fizeau Interferometry with LBT - Astronomy on the way to ELTs

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The next generation of optical and near-infrared telescopes are planned to have a collecting area with a diameter of 20 to 100 m. This does not only increase the amount of photons which can be collected but also the spatial resolution of the images you receive. The Large Binocular Telescope (LBT) exists of two 8.4m mirrors with a center-center separation of 14.4m delivering in the combined focus already a spatial resolution of a 23m class telescope. We are building a Fizeau interferometer for the LBT working in the near-infrared wave band which is taking advantage of this capability. With explanation of the instrument and its science cases we show how it can not only be used as technical test bench for ELTs but also can deliver first results we expect from Extremely Large Telescopes (ELT). A further interesting point of this instrument, we want to target, is that the data reduction techniques needed have similarities to well known techniques in the radio astronomy.

14

MUSE: 3D Spectroscopy with large telescopes

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Astrofysikalisches Institut Potsdam (AIP)

The Multi Unit Spectroscopic Explorer (MUSE) is a second generation instrument in development for the Very Large Telescope (VLT). It is a panoramic integral-field spectrograph operating in the visible wavelength range. It combines a wide field of view with the improved spatial resolution provided by adaptive optics and covers a large simultaneous spectral range. MUSE couples the discovery potential of an imaging device to the measuring capabilities of a spectrograph. This makes it a unique and powerful tool for discovering objects that cannot be found in imaging surveys. MUSE is a project of 8 european institutes led by the Centre de Recherche Atronomique de Lyon (CRAL). The paper summarizes the instrument capabilities and presents the AIP contributions to the science cases, the design of the calibration unit and the data reduction and analyses software.

15

Layer-Oriented MCAO projects for 8-m class telescopes and possible scientific outcome

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Four projects exploiting Multi Conjugate Adaptive Optics with Layer-Oriented wavefront sensing technique are being developed by our group in this period. The purpose of these projects is, in some cases, to give experimental evidence to the Layer-Oriented concept, developed in the last few years. In some other cases, to build real facilities to be used in 8-m class telescopes, like VLT in Chile or LBT in Arizona. A brief description of these project will be given while indeed an analysis of the possible scientific outcome which can be obtained when reaching diffraction limit images in the near infrared using MCAO will be performed.

16

Prospects for an Extremely Large Synthesis Array

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Leiden University

An Extremely Large Synthesis Array (ELSA) with 27 ten-meter telescopes and baseline lengths up to 10 km, operating in the visible and near-infrared, would provide completely new insight into many astrophysics phenomena. It could be used to obtain resolved images of nearby brown dwarfs which would reveal weather phenomena in their atmospheres, to give detailed pictures of stellar surfaces and interacting binaries, to study general-relativistic effects on the orbits of stars near the center of our Galaxy, to obtain “movies” of expanding supernovae, to image the broad-line regions of active galaxies, and to measure the geometry of the fireballs producing the afterglow of gamma-ray bursts.

Observations of faint objects will be possible by using an external reference star to co-phase the array. Telescopes with large diameters are essential to provide good sky coverage in this observing mode. The use of optical fibers for beam transport and delay compensation is highly desirable, as this eliminates the need for an expensive beam train with meter-sized optical elements, and a very large vacuum system.

Advances in telescope technology and fiber optics expected for the next decade may bring the cost of ELSA into a range that would be affordable for an international project.

17

Instrumentation for the Thirty Meter Telescope Project

Keith Taylor

Caltech

The TMT project is a 4-way partnership between the earlier California Extremely Large Telescope (CELT) project, the Giant Segmented Mirror Telescope (GSMT) project and the Canadian Very Large Optical Telescope (VLOT) project. A cross-partnership TMT instrument working group has now been set up to explore the challenges posed by both seeing-limited and AO-fed instrumentation for the TMT which is extending the work done in the Phase-A studies for CELT, GSMT and VLOT. We report here on the evolution of thinking in constructing an initial instrument suite which includes not only massively multiplexed UV/optical seeing-limited multi-object spectroscopy but also on plans for wide-field adaptive optics fed integral-field spectroscopy and imaging at, and approaching, the TMT's diffraction limit.

18

Interferometry in the Near-Infrared

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High-resolution interferometric imaging at optical and infrared wavelengths provides unique information for the study of many different classes of astronomical objects. A large number of key objects has been resolved with unprecedented resolution using speckle interferometry or infrared long-baseline interferometry. We present interferometric observations of bipolar outflows and other structures of young stellar objects, the atmosphere and dust shells of evolved stars, as well as the circumnuclear dust environment of active galactic nuclei. The observations were carried out with the SAO 6 m telescope, the KECK 10 m telescope, the IOTA interferometer, and ESO's Very Large Telescope Interferometer. The combination of interferometry and radiative transfer modeling allowed quantitative physical interpretations of the observations. Based on results obtained with existing interferometers, we discuss the potential of future interferometers.

I(d) UV and high-energy astronomy

19

**Electrical and geometrical characterization of the Silicon flight sensors
of the GLAST/LAT tracking system**

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University and INFN Bari

GLAST/LAT is a telescope for gamma rays in the range 20MeV-300GeV. It consists of a Silicon Strip Detectors (SSDs) Tracker, a CsI calorimeter and an anticoincidence detector. The total surface of silicon detectors is almost 80m² so it will have the largest equipped area among all space experiments. In this paper will be presented the electrical and dimensional tests performed on almost 8000 flight SSDs, the ladders assembly procedures and the electrical and geometrical tests on the first 900 flight sensor.

20

Environmental Testing of the GLAST Tracker subsystem

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GLAST, the Gamma Ray Large Area Space Telescope, is a high energy gamma-ray astronomy mission planned for launch in the early 2007. It consists of the Large Area Telescope (LAT), to search for γ -rays in the energy range from 20 MeV to 300 GeV, and the Gamma-ray Burst Monitor (GBM) for high variability phenomena studies. The LAT is composed by a silicon micro-strip detector tracker followed by a segmented CsI calorimeter, to reconstruct γ -rays direction and energy, and an anticoincidence system to reject charged particle background. As a detector for space application, vibration tests and thermal-vacuum cycling are required to demonstrate the optimal performance in the expected mission environment. The results of the environmental tests performed on the Engineering Model Tower of the GLAST LAT Tracker and on the first flight components (trays) are presented.

21

The potential of a Large Cherenkov Array for Supersymmetry and Cosmology

Edmond Giraud

GAM-UM2

Cosmological N-body simulations of cold dark matter have revealed the survival of a large number of substructures within galactic halos. Some of them may be identified with dwarf spheroidal satellites (dSph) and globular clusters. For what concerns non baryonic matter, physics beyond the standard model may be supersymmetry. The galactic center (GC) and the dSphs have long been considered as the best candidates for indirect search of dark matter either because of its small distance (GC) or of their huge mass-to-light ratios (dSphs). Probing a large fraction of the supersymmetric parameter space by assuming that some of the galactic structures are made of neutralinos is one of the present day major scientific issues.

An array of 16-20 Cherenkov reflectors with diameters 18m, located at high altitude (5000 m), has the potential of exploring a significant fraction of the supersymmetric parameter space.

This instrument will combine wide angle cameras in units of 4-5 telescopes operated in stereoscopic mode, and large detection areas by using a grid of such units.

The LCA will also serve as a major tool in Observational Cosmology and Astrophysics above 10 GeV up to 1 TeV. It will address the questions of the Cosmological gamma-ray horizon and the infrared background, and will see the bulk of the cosmological AGNs. It will detect more than 100 times sources than EGRET and will be able to study the emission of radio-galaxies and will reach clusters of galaxies. Physics of nearby objects like pulsars and supernova remnants will be studied with unprecedented statistics, as well as synchrotron flares of micro-quasars and distant gamma-ray bursts. Finally it will allow to understand the origin of the extra-galactic background and determine the contributions of AGNs, BL Lacs, FSRQs, topological defects, SUSY disintegration. Coming after GLAST, a LCA will allow studying in details, at higher energy, the sources detected by this satellite.

A very interesting site would be the Chajnantor area for this project which requires clear UVB photometric nights high altitude and sufficiently high geomagnetic cutoff.

22

LOBSTER - Astrophysics with Lobster Eye Telescopes

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We refer on the project of a Lobster X-ray All Sky Monitor and on the related developments of the innovative Lobster Eye X-ray telescopes. The related scientific issues will be also in detail presented and discussed.

23

Innovative Technologies for Future Large X-ray Telescopes

R. Hudec, L. Pina, A. Inneman, V. Brozek

Astronomical Institute Ondrejov, Czech Technical University Prague, Reflex sro Prague, Institute of Chemical Technology Prague

The future large X-ray telescopes will require light-weight and precise mirror shells. We refer on the development on innovative technologies for future large X-ray telescopes like the ESA XEUS Project. These technologies include light ceramics replication, glass technology, amorphous metals, and glossy carbon.

24

GLAST Large Area Telescope Science Prospects

Olaf Reimer, GLAST LAT collaboration

Ruhr-Universitt Bochum, Institut fr Theoretische Physik IV

The Large Area Telescope (LAT), a pair-conversion telescope that provides coverage over the approximate energy range 20 MeV to 300 GeV, is the principal instrument on the GLAST Mission. The LAT will provide an unprecedented capability for high-energy astrophysics, superceding the sensitivity of EGRET by more than 40 times. Highlights of the physics and astrophysics opportunities the GLAST LAT will provide will be summarized.

I(e) Virtual Observatories

25

Digitized Astronomical Plate Archives

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There are about 3 million archival astronomical plates around the globe, covering the entire sky for about 100 years. I will report on the recent efforts to digitize the sky plate archives and to use these data for various scientific projects. I will also address and discuss the status of the development of related algorithms and software programs. These data may easily provide very long term monitoring over very extended time intervals (up to more than 100 years) with limiting magnitudes between 12 and 23. I will further discuss the projects of a centralized astronomical direct plate archives and digitization facilities in order to make these photographic data fully available for scientific research. I will outline details of these project as well as related discussions.

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Virtual Observatories and access to interferometry archives

Anita Richards¹ and the AVO/AstroGrid/MERLIN/EVN archive team

Jodrell Bank Observatory & Astrophysical Virtual Observatory

Radio astronomy and other interferometry data are no longer the exclusive province of the expert. Pipelines and other user-friendly tools are now common. The multitude of possible fields, resolutions, time-series and so on, which can be extracted from a single interferometry dataset, are at last becoming accessible, albeit usually via the observatories' individual web sites. The new generation of interferometers (ALMA, e-MERLIN, eVLA, SKA) will have data access for non-experts designed into their archives. This is made possible by the development of Virtual Observatories coordinated through the IVOA.

The next step for VOs and data providers is to provide interfaces so that data can be extracted from any registered archive without forcing the user to visit many sites. Some current projects will be described, including the inclusion of MERLIN data in AstroGrid and AVO and Virtual Observatory science achievements in developing classification and discovery methods for YSO and high-z obscured sources.

II. Fundamental Physics and Cosmology

27

SSF as protoobjects in Dark Ages epoch: theory and experiment

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In order to investigate Dark Ages epoch of the Universe evolution observational effects caused by primordial molecules seem to be most promising. The basic properties of molecules are discrete narrow lines and high efficiency of its interaction with CMBR. This leads to forming Spectral Special Fluctuations (SSF) of CMBR temperature by protoobjects moving with specific velocities relative to CMBR. Our estimates of SSF amplitudes and spectral parameters obtained on the base of standard model of velocity distribution of protoobjects and primordial chemical abundance are presented. Expected values of dT/T may reach 10^{-5} – 10^{-6} and bandwidth of the lines is 0.1-1% depending on the scale of protoobjects and redshifts. For this task CMBR maps obtained in different nearby narrow spectral channels are to be observed and then treated by special differential methods. First attempts of such observations were made at RATAN-600 (SAO RAS, Russia) at 6 cm and now we have plans to use MSRT (Tuorla Observatory, Finland) equipped by 7 beam microbolometer array at 3 mm with chopping flat and frequency multiplexer providing 7 spectral channels in each beam. Actually, in the nearest future the best results in this field can be obtained with ALMA facilities.

28

Astroparticle Physics with AMS-02

Emanuele Fiandrini, for the AMS Collaboration

INFN-Perugia

(cancelled)

29

Potential for indirect Dark Matter Detection with Gamma-Ray observatories

D. Horns¹, B. Degrange², for the H.E.S.S. collaboration

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(cancelled)

30

Cosmic-ray Astrophysics with AMS-02

Elisa Lanciotti, for the AMS Collaboration

CIEMAT, Madrid

Precise knowledge of the hadronic component of cosmic rays is needed to describe the cosmic ray production, acceleration and propagation mechanisms in our galaxy. Present measurements suffer from limitations coming from short exposure time, intrinsic instrumental limitations and restricted energy range. The AMS-02 experiment is a large acceptance magnetic spectrometer to perform high statistics studies of cosmic rays in space. The detector will operate on the International Space Station for more than 3 years. AMS-02 will precisely measure the cosmic ray fluxes of individual elements up to Z 25 in the rigidity range from 1GV to 1TV. AMS-02 will allow to test propagation models through the precise measurements of secondary-to-primary ratios as D/p, 3He/4He in the energy range few hundreds MeV to tens of GeV, and B/C, sub-Fe/Fe up to 1TV. In particular the original measurements of 10Be/9Be will be performed with high accuracy allowing the understanding of the age of the cosmic-ray confinement and constraint models of the size of the galactic halo.

31

Studying the Nature of Dark Energy with Current and Future Instruments

Thomas H. Reiprich

University of Virginia and University of Bonn

The nature of dark energy is a mystery and, currently, one of the most important riddles in cosmology and fundamental physics. Among others, observations of galaxy clusters at low and high redshift can be used to place constraints on the equation of state of dark energy. I'll report on our efforts to study dark energy with the best currently available X-ray and optical instruments (Chandra, XMM-Newton, and large aperture optical telescopes equipped with wide field imagers), discuss the limitations, and the need for future instruments (especially ROSITA, DUO, XEUS, and Constellation-X).

32

Project ASTRAL: All-Sky Telescope to Record Afterglow Locations

G.S. Tsarevsky^{1,2}

(1) – Australia Telescope National Facility, Sydney, (2) – Astro Space Center, Moscow

ASTRAL is a project incorporating wide-field optical telescopes on board a small satellite dedicated to the whole-sky detection of a variety of rapid astronomical phenomena, particularly optical flashes associated with gamma ray bursts (GRB). Those flashes only visible optically (so called "orphans"), as well as those preceding associated GRBs, cannot be detected in the current triggering mode of the world wide GRB Coordinates Network (GCN). Hence ASTRAL would have a unique opportunity to trigger a follow-up multi-frequency study via GCN. ASTRAL consists of a set of 13 wide-field cameras (each with FOV = 70°) equipped with 4096x4096 CCDs. The detection method is based on the Digital Blink Comparator mode, with a template of a complete sample of 2 million stars down to 12^m, precisely measured in the HIPPARCOS and TYCHO-2 missions. Supernovae, novae and nova-like explosions, fast variable AGNs, flare stars, and even new comets would be promptly detected as well. Monitoring of Near-Earth objects (NEO) is of special interest. Thus ASTRAL would be an original working prototype of the prospective major space mission to monitor on-line all the sky down to 25^m - a high priority instrument of 21st century astrophysics. See <http://www.atnf.csiro.au/people/Gregory.Tsarevsky/ASTRAL.ppt> for details.

III. High-redshift Universe, Galaxies, Galaxy Evolution

33

Observations of Galaxies in rest-frame UV, the UV satellite GALEX and ground-based ELT and JWST Science Objectives

Denis Burgarella

Observatoire Astronomique Marseille Provence

GALEX is a 50-cm satellite launched in 2003 dedicated to the observation of the sky in ultraviolet (from 130 to 300 nm). The whole sky will be observed for the first time in ultraviolet and several other surveys in imagery and spectroscopy are building up. One of the main goals of the 21st century telescopes (JWST and ground-based ELT) will be to observe the high redshift universe, which means observing the rest-frame ultraviolet emission of the first objects formed. GALEX will therefore be crucial to prepare the science program of these telescopes in a first phase and to interpret the observed data in a second phase. I will therefore present GALEX, its first science results and how it relates to science goals of next generation of telescopes like ground-based Extremely Large Telescopes and the James Webb Space Telescope.

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The relic source B2 0924+30 – A prototype of a rich source population at very low frequencies?

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Relic radio galaxies are generally defined as sources without any sign of activity like strong cores, jets or hot spots. They are very rare, only about a dozen of such objects are known which compared with the abundance rate of active radio galaxies is puzzling. This scarceness must imply that both, the ‘switch-off’ of the central engine as well as the fading of the radio lobes come off relatively rapidly.

Here we present an exemplary study of B2 0924+30, one of the very few relic sources which could be detected up to relatively high radio frequencies. The object shows a synchrotron spectrum as steep as 1.6. A spectral ageing analysis including nine different measurements at frequencies between 151 MHz and 10.6 GHz yields particle ages between 70 and 80 Myrs, a relatively short period since switch-off, which explains why relic sources would easily escape detection in the GHz frequency range.

The steep spectral indices and the paucity of these sources require the employment of sensitive antennas at low frequencies and good angular resolution. LOFAR will be the prime instrument to increase the statistics of relic galaxies and to observe them in great detail. As the relic state is the endpoint in the life of each extragalactic radio source, the study of this phase fills an important gap in source evolution scenarios.

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Study of extragalactic sources with extended radio emission.

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Radio galaxies which extend over more than one Megaparsec represent the biggest single objects in the Universe. In the past few years such giant radio galaxies (GRGs) have received special interest in a number of astrophysical problems. They provide important constraints on the evolution of galaxies and the cycles of AGN activity. GRGs are also crucial in studying the density and cosmological evolution of the intergalactic and intracluster medium.

GRGs possess steep radio spectra, a low surface brightness, and the bulk of them have very large angular sizes (a few tens of arcminutes on the sky). Therefore, only a small fraction of expected faint GRGs have been detected and mapped at high (~ 1 GHz) radio frequencies so far.

In this contribution we emphasize the crucial role of low frequency, high dynamic range and sensitive observations of GRGs. We argue that the new generation of radio telescopes like LOFAR and SKA will be ideal instruments for the study of GRGs.

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The B3VLA sample at low frequencies – results from a survey at 74 MHz

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The low-frequency (< 150 MHz) region is among the most poorly explored of the entire radio spectrum despite the many unique astrophysical questions that can be addressed with observations in these bands. In the framework of our on-going study of the radio continuum spectra of the B3 VLA survey we have used the observations of Tschager et al. (2003, *A&A* 402, 171) obtained with the VLA in A-array at 74 MHz to extend our database towards lower frequencies. For about a third of the sample (some 360 radio sources) we have now 6 or more measurements in the range between 74 MHz and 10.5 GHz. This unique frequency coverage allows consistency checks of the new 74-MHz flux densities and provides the comparison data to test the influence various observational effects at such low frequencies.

We have performed a spectral analysis to determine particular features like low-frequency turn-overs caused by synchrotron self-absorption or free-free absorption. Some radio sources show extended and complex morphologies not seen at higher frequencies, indicating the presence of diffuse structures with very steep spectra. Our project is an example of a typical application of the future LOFAR telescope in the field of source evolution studies.

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Modeling the composition of the nanoJy radio sky as a function of redshift

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The apparent change in the composition of the parent optical objects of radio sources around 1 mJy (at 1.4 GHz) has now been well established, although there is still some debate about the relative importance of classical radio galaxies and star-forming galaxies at sub-mJy levels (see e.g. Grappioni et al. 1999, Prandoni et al. 2001b). It is clear, however, that at microJy levels star-forming galaxies are dominant (see Fomalont et al. 1997, Haarsma et al. 2000). Does this mean that SKA will basically tell us more about the history of star formation than about the space density (and cosmological evolution) of AGNs? Hopkins et al. (1999) have simulated the radio sky at SKA levels. In this work we go one step further and ask ourselves what kinds of objects we can expect to find at various radio flux levels and redshifts. Using current best estimates of luminosity functions of various types of objects (spirals, starburst galaxies, radio galaxies, quasars, low luminosity AGNs, ecc.) we show that the increasing dominance of star-forming galaxies below 1 mJy is a natural consequence of the different luminosity functions, but that this does not at all mean that star-forming galaxies do necessarily dominate at all sub-mJy flux levels and all redshifts. Much depends on the radio/optical evolutionary properties assumed for them. Other important issues are the role played by the low luminosity AGNs and the role played by obscured objects.

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Radio view of cluster mergers

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We will present our work on mergers in clusters of galaxies, with emphasis on the open questions which are expected to be addressed by the forthcoming astronomical instrumentation.

IV. AGN and Compact Objects

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The innermost AGN jets with future mm-VLBI

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We will discuss the impact of possible future Global-mm VLBI arrays in our knowledge of the central engines of AGNs. The phased mm-interferometers CARMA, EVLA, VLBA, Plateau de Bure, ALMA are suitable to participate in such arrays. If so, future highly sensitive and angular resolution (0.05 mas) observations will allow to obtain high dynamic range images of the innermost jet regions for a large fraction of known AGNs. This studies can provide important observational information about the less known region in extragalactic jets, as well as about their initial formation, collimation and acceleration mechanisms. The results of our recent CMVA images of the mm-jet in NRAO150 will be presented as a present example of the future observations and results to be obtained. At present, this kind of observations can be performed only for a few, very intense, mm-jets.

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VLBA surveys and preparation of the "RadioAstron" mission

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Results of data processing of various VLBA observational sessions are presented. These observations have been carried out in 1994 - 1999. More than 300 sources were observed. Many of them are from source listing of the "RadioAstron" mission is being prepared. VLBA data processing results provide us with information about these sources radio structure, and this information is necessary for such preparation. Images of many AGN and Compact Objects at various frequency ranges are presented. All results have been obtained with the imaging software titled "Astro Space Locator" (ASL for Windows).

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The radio properties of low power BL Lacs

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We will present new radio data for a sample of 30 nearby ($z \lesssim 0.2$) BL Lac objects. The sample is composed of both high and low luminosity sources and it is therefore an ideal test bed for unified schemes in the low power regime. Data on parsec and kpc scale are used, thus providing information on both extended and inner, beamed components. Among the main results, we will also present a comparison to high quality HST data, as well as to X ray properties. Thanks to future instruments, it will be possible to perform a similar study for more distant and possibly different members of the BL Lac class.

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Probes of Jet-Disk-Coupling in AGN from combined VLBI and X-Ray Observations

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The physical conditions of accretion flows in the direct vicinity of supermassive black holes in AGN can be studied via X-ray spectroscopy. Such observations probe physical regions comparable in size to the typically resolved portions of parsec-scale radio jets in Very Long Baseline Interferometry (VLBI) experiments. Particularly, structural variability of relativistically broadened AGN iron lines provides a powerful tool to study dynamical processes in the accretion flow and their influence on jet formation: the time variability of the iron line profile from the center of the LINER galaxy NGC1052 appears to be associated with the ejection of new components into the parsec-scale jet. NGC1052 is the only example of a radio-loud, core-dominated AGN so far, which exhibits strong broad iron line emission. In our talk we will discuss how new generation X-ray missions, like Constellation X, and future radio interferometric arrays, such as the SKA, will allow us to explore the detailed inter-relation between the accretion flow and the formation of relativistic jets in AGN.

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On the way to the event horizon - high resolution imaging of AGN

T. P. Krichbaum, A. Zensus, et al.

MPIfR, Bonn

Imaging the jet base of AGN and the inner most region of the Galactic Center with mm-VLBI has the potential of detecting GR effects near the SMBH. The present status of mm-VLBI, which todate provides the highest angular and spatial resolution in Astronomy, is given. New results are presented. Future prospects are discussed, taking into account new mm-observatories like CARMA and ALMA.

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Two-component model of AGN Broad Line Region

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In order to explain the complex broad lines of AGNs, we apply the two-component model assuming that the line wings originated in a very broad line region (VBLR) and line core in an intermediate line region (ILR). The VBLR is assumed to be an accretion disk and ILR a spherical region. Such a model can very well fit complex broad lines of AGNs (Popovic et al., 2002, A&A, 390, 473, Popovic et al. 2003, ApJ, 599,185). Moreover, it seems that the physical conditions in region which contribute to the line core and line wings are different (Popovic 2003, ApJ, 599, 140). We will discuss the model and kinematical parameters obtained from the fitting of AGN complex broad lines.

V. ISM and Formation and Evolution of Stars

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Interrelations between Strömgren and Vilnius photometric systems: an improvement of stellar classification

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During recent years considerable efforts have been aimed at the development and use of photometric systems, applicable to very large samples of stars and under the constraints of space-based observations. In this contribution we discuss some aspects of the Strömvil system which, because of its classification power, is among the photometric systems considered for a comprehensive study of the Milky Way during future space missions. These systems should be capable of recognizing stars of most spectral types and peculiarities in case of high and non-uniform values of interstellar absorption. In general, these are multi-color intermediate-band systems assuring stellar photometry of very high precision, robustness of the system transformability against different implementations and capability of determining stellar parameters precisely. On the basis of a number of empirically derived relationships between Vilnius and Strömgren photometric quantities, we show that a photometric index $v - X$ may find applications for quick diagnostics of the stellar content of large samples of stars and may be applied to study both the Milky Way and other galaxies. This photometric quantity is easily achievable observationally, virtually unaffected by the interstellar absorption and looks promising for fast classification of stars of moderate and low surface temperature. This presentation discusses possibilities to calibrate the $v - X$ difference as a reddening free $\log g$ indicator for G-K2 stars of moderate luminosity.

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HH 110 PROPER MOTIONS

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The HH 110 jet presents a complex morphology in the optical images, with noticeable wiggles along the length of the jet. This structure suggests a turbulent outflow. Here we present new results of the kinematics of HH 110. New proper motion measurements have been calculated from deep [SII] CCD images obtained with a time baseline of nearly fifteen years. We explore the feasibility of the scenario proposed by several authors to explain the complex morphology of this jet: HH 110 appears as the result of a grazing collision of the HH 270 jet (another fainter jet, to the NE of HH 110) with a dense molecular clump of gas, from which HH 270 is deflected into HH 110.

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The effect of the Galactic gas radial distribution on the expected Cosmic Rays Spectrum

Mercedes Mollá

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We will analyze the importance of varying the diffuse gas radial distribution on the expected cosmic rays spectra by using the most recent HI density data published by Nakanishi et al.(2003). By including this new distribution in the cosmic ray propagation code GALPROP from Strong & Moskalenko (1998), we will obtain those models able to reproduce the characteristic shown by the cosmic rays measurements. Thus, from the values taken by the parameters of these models we will extract some information about the Galaxy structure.

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Exploring the star formation in the Galactic Center: from ISO to ALMA

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The infrared to radio range is the best suited to study the early stages of star formation. Dense cores resulting from protostellar collapse first appear as (sub)millimeter sources, and can be mapped through the continuum emission of cold dust, or through emission lines from molecular tracers. When a protostar or protocluster has formed, the surrounding material gets warmer, and the emission moves towards the infrared. In this talk, I will show how large scale mid-infrared surveys (ISOGAL, MSX) can be exploited to roughly estimate the average star formation rate in the peculiar environment of the Galactic Center. I will then show how various follow-up observations will increase our knowledge about the star formation in this region, from already planned projects with mid-term available telescopes (APEX, Spitzer) to future projects making use of major facilities, such as ALMA.

Future Observations of Cosmic Masers

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Water vapor, hydroxyl and methanol masers are powerful tools for study star formation process in our Galaxy, as well as for measuring parameters of nuclei in active galaxies. It is still not known whether the maser spots trace outflows from young stars and protostars, or their pattern follows configuration of circumstellar or circumnuclear disks. In the latter case the maser spots may show position of proto-planets forming in the disks. Both scenarios can be true either. The structure of the individual maser spots are poorly known, mostly due to the lack of spatial resolution. Galactic and extragalactic distance scales can be established or tested independently using high angular resolution observations of cosmic masers. Future observations of cosmic masers will require VLBI and Space VLBI measurements of the structure of maser spots and their proper motion relative to the extragalactic reference frame. It is suggested that a dedicated space-VLBI mission working in conjunction with SKA has to be considered for the exploration of cosmic masers. It will operate at four frequencies of OH, methanol and H₂O from 1.6 to 22 GHz, and the orbit of the satellite bus can have variable apogee from 10,000 km to 300,000 km, in order to obtain a full range of angular resolution.

VI. Planets and Origins of Life

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Planetary science with HIFI and SAFIR - a comparison

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Max-Planck-Institut für Aeronomie

(cancelled)

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Towards high-precision astrometry - Differential Delay Lines for PRIMA at VLTI

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Deriving all orbital parameters and exact masses of extrasolar planets requires at least 2-dimensional information on either the positions or motions of the planet directly (currently out of reach) or, indirectly, of the host star. The latter can be achieved with high-precision astrometry at the 10 microarcsec level, especially when combined with radial velocity measurements. To achieve this goal, a consortium with partners from Germany, Netherlands, and Switzerland, in agreement with ESO, will enhance the PRIMA system at the VLTI with Differential Delay Lines (DDLs). The purpose of the DDLs in differential (phase-referenced) astrometry is to separate the large OPD correction terms which are common for target and reference star (to be corrected with the main delay lines) and the small differential terms (to be corrected under vacuum with the smaller and more precise DDLs). We will give an overview on the project, which is now in the preliminary design phase, and present the technical baseline design, as well as outline the scientific research plan.