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A NEW GENERATION OF INFRARED SKY SURVEY FOR THE E-ELT ERA

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Abstract. A New Generation Infrared Sky Survey (ANGISS) is proposed for the next decade offering performances matching the requests of the new extremely large telescopes such as the E-ELT in order to prepare and follow-up their programmes. This will require the coverage of thousands of square degrees at K $\sim$ 25 or better, with an angular resolution of $\sim$ 300 mas and time domain exploration. Set up on the Antarctic Plateau, a NGISS using a relatively modest telescope (2.5 to 4 m) looks particularly attractive. Moreover, an off-axis optical combination is preferred to fully benefit from the exceptional atmospheric properties of the site and to explore the 2.3-4 m window in optimal thermal emission conditions.

Keywords: off-axis telescope, infrared astronomy, Antarctic astronomy

1 Introduction

A new era for optical/IR astronomy will begin by the end of this decade with JWST, LSST, EUCLID and 30/40 m class ground based telescopes such as the E-ELT. Such instruments providing gains in sensitivity of several orders of magnitudes will require new large scale surveys (such as LSST) that will accompany their missions and key-programs to single out and follow-up new sources. Renewed canonic documents such as digitized catalogues and maps will be required. In the infrared range, projects are currently proposed to supersede 2MASS by a factor $\sim$ 1000 in sensitivity and $\sim$ 3 in angular resolution, such as SASIR in the Northern Sky. We propose a project of a New Generation Infrared Sky Survey (NGISS) for the Southern sky that could benefit from the Polar atmospheric conditions to optimize the performances and to extend the spectral coverage beyond 2.3μm.

2 Requirements and performances

The 2MASS survey is not deep enough for preparing, accompanying and making the follow-up of ELT IR key-programs. A NGISS should also supersede VISTA in sky coverage, sensitivity, angular resolution and spectral range. Its coverage of the Southern Sky will be 5 to 15 000 square degrees and its high sensitivity bring a of gain $\sim$ 1000 with respect to 2MASS at K. Figure 1 compares NGISS sensitivity to other surveys. Its off-axis telescope design reaches a high contrast and thanks to the site qualities added to a GLAO system, a high angular resolution of 0.3 arcsec or better is obtained. With an extend spectral coverage beyond 2.3μm (in particular the K dark and L windows) ANGISS will bridge ground and space surveys (WISE, Spitzer,).

The PLT would be the most sensitive instrument ever installed on the ground at 2μm pushing the limit at least 2 magnitudes below the VISTA achievement (Dalton 2010). Table 1 summarizes the point source and extended object limiting sensitivities (in AB magnitudes) for a 5σ, 1 hour integration, assuming that the sky background is summed over 4 times the FHWM disc (for point sources), that the telescope temperature is stabilized at 227 K with 5% emissivity, and the overall optical efficiency is 50% (including throughput, detector efficiencies, and secondary mirror obscuration).

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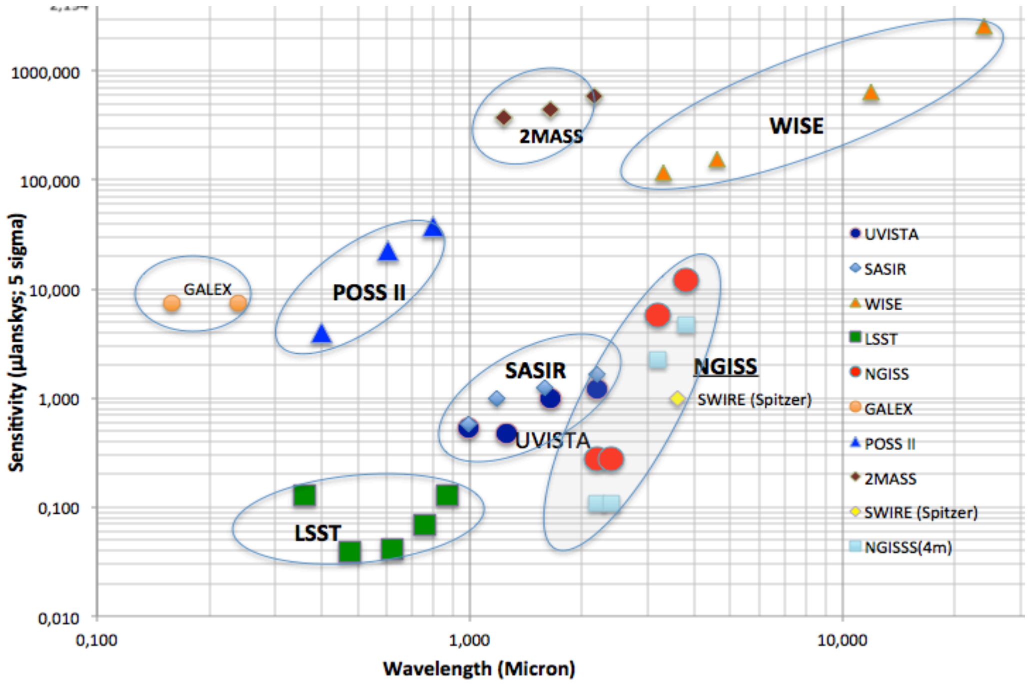

Fig. 1. The expected sensitivity of NGISS compared to other surveys

Band	λ (μm)	**R** ($\lambda/\Delta\lambda$)	**FWHM** ($''$)	$\mathbf{m_{AB}}$ mag.	$\mathbf{m_{AB}}$ /arc^2
Kd	2.40	10	0.32	25.3	24.7
Ls	3.40	6	0.38	20.8	20.1
L$'$	3.76	5.8	0.40	21.2	20.8
M	4.66	19	0.46	19.6	19.4

Table 1. Expected sensitivity of the PLT adapted from Lawrence 2009

3 Top sciences drivers

The science cases for which observations in polar environment could bring important breakthroughs was debated at the international level, particularly in Europe within the former ARENA network (*see,* Epchtein and Candidi 2007, Zinnecker, Epchtein and Rauer 2008, Spinoglio and Epchtein 2010), Three top science drivers that will take benefit from a NGISS are pinpointed:
(i) the distant universe: high redshift galaxies. The H_2 line is one of the main tracers of star formation. It lies in the K band for $z = 2$ to 3, the peak for star bursts in the evolution of galaxies. In the L band the $z = 4$ to 5 range can be explored. Survey and light curve follow-up of type Ia Sne in dusty galaxies would allow to improve constraints on the cosmological parameters derived from SNIa.
(ii) Extragalactic stellar populations: a synoptic time monitoring of Magellanic Stellar populations (extension of VMC- deeper- $\lambda > 2.3\mu$m) in order to understand star formation processes and extreme populations of AGB stars.
(iii) Low mass stars and exoplanet science: K and M–type stars have their maximum brightness in this spectral domain, allowing a systematic study of planets around these stars. Such a census is necessary for a full appraisal of the planet formation process. The transit and micro-lensing techniques of detection and characterization of exoplanets can benefit from the unique properties of Dome C. Applying these in the near infrared can enable to reach a remarkable depth.

4 Instrumental concept

Such an IR facility installed in an exceptional site should have: (1) the highest possible dynamic range, (2) the best angular resolution and (3) wide-field imaging capabilities in the near- and thermal-infrared range.

At Dome C, the boundary layer contributes to 90% to the total integrated atmospheric turbulence. If this low turbulence is corrected, then Dome C appears to be twice as good as the best temperate siteswith a median free-atmosphere seeing of about 0.3 arcsec at 500 nm. Isoplanatic angles are larger by a factor of two to three at any altitude compared to other ground-based sites and reaches about 6 arcsec. To reach such a goal, ground-layer adaptive optics (GLAO) has been proposed.

A telescope that optimally meets the science and site performance possibilities is an off-axis telescope. An off-axis telescope can have a superior constrast because it provides an inherently low scattered light design because there are no obstructions in the beam. There are a minimal number of scattered light sources. All mirrors can be robustly supported and articulated because of the easy access allowed by this design. All warm components, sources of the telescope self-thermal emission, will be out of optical beam minimizing its emissivity allowing observations in the K and L-windows. Thus it has a tremendous advantage for detecting faint planets around star. Another advantage is for adaptative optics performances because this configuration has no azimuthal PSF structure, no extrapolated wave front errors. A description of this configuration can be found in Moretto et al.(2012) and Moretto et al. 2012b.

5 Project for an assessment study

We propose a project whose major objectives are:
(1) to define the sciences cases that a new survey could tackle notably in synergy with the coming extremly large telescopes and space missions like E-ELT, EUCLID, JWST. These topics must be precise topics in which observations in polar conditions will bring important breakthroughs;
(2) to design and build a 0.5 - 1 m prototype off-axis telescope to validate the concept;
(3) to design a GLAO device compliant with the specific atmospheric turbulence properties of the site; and
(4) to monitor the sky background emission in K and L-bands at the franco-italian polar station of Concordia, using IRAIT.
Our final goal is the design of 3 - 4 m telescope that would be operational in the beginning of the early 20's, at the E-ELT's arrival.

6 Conclusions

A New Generation Infrared Sky Survey is proposed for the next decade offering performances matching the requests of the new extremely large telescopes such as the E-ELT in order to prepare and follow-up their programmes. This will require the coverage of thousands of square degrees at mag in K better than 25, with an angular resolution of 300 mas and time domain exploration. In the Southern hemisphere, a NGISS using a relatively modest aperture telescope (2.5 to 4 m) set up on the Antarctic Plateau at Dome C looks particularly attractive. Moreover, an off-axis optical combination is preferred to fully benefit from the exceptional atmospheric properties of the site and to explore the $2.3-4\mu$m windows in optimal thermal emission conditions.

References

Moretto G., Epchtein N., Langlois M., Vauglin I., Proc. of SPIE Vol. 8444, 84445E, 2012

Gredel, R., Proc. 3rd ARENA Conf., eds. L. Spinoglio & N. Epchtein, EDP EAS Ser. Vol. 40, 11, 2010

Moretto G.,Vauglin I.,Langlois M., Epchtein N., Proc. SF2A 2012, Eds S. Boissier, P. de Laverny, N. Nardetto, R. Samadi, D. Valls-Gabaud, H. Wozniak, pp. 707, 2012

Epchtein N. (coordinator) and the ARENA consortium, 2010, *A Vision for European Astronomy and Astrophysics at the Antarctic station Concordia, DomeC*, the ARENA roadmap, Novaterra (http://arena.unice.fr)