THE WIDEFIELD INFRARED SURVEY EXPLORER: NEW FRONTIERS IN GALACTIC SCIENCE.

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Introduction: The Widefield Infrared Survey Explorer (WISE; Prof. Edward Wright of UCLA is the Principal Investigator), launching in 2009, will survey the entire sky at 3.3, 4.7, 12, and 23 µm [1], [2], [3]. With a sensitivity 500x better than IRAS at 12 and 23 µm and 500,000x better than COBE at 3.3 and 4.7 µm, WISE will open up new frontiers in galactic science. The WISE survey will extend the Two Micron All Sky Survey (2MASS) into the thermal infrared.

Recent data from the Spitzer Space Telescope have shown the power and utility of mid-infrared observations for a wide range of problems in galactic science.

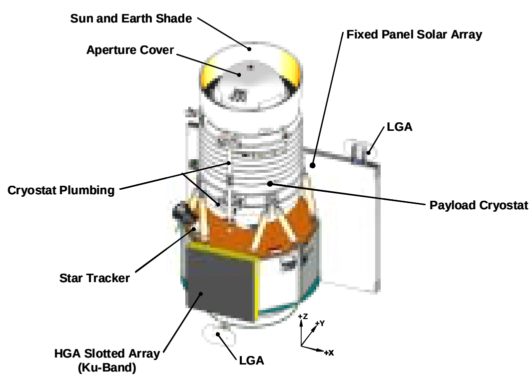

Figure 1: The WISE Observatory.

However, as a pointed telescope, Spitzer will only survey ~1% of the entire sky. Wide, shallow surveys present the optimal method for finding superlative and/or unique objects. Examples include near-Earth asteroids from Spacewatch, planetary debris disks from IRAS, and L and T-dwarf stars from 2MASS.

The final output of the WISE mission will be an all-sky catalog. WISE will deliver over one million calibrated rectified images covering the whole sky, and catalogs of up to half a billion objects, in four bands. WISE's two primary science goals are the detection of the nearest stars to our Sun and the most luminous galaxies in the universe.

WISE will employ four 1024x1024 detector arrays (two HgCdTe, two Si:As) which reach sensitivity limits of 120, 160, 650, and 2600 µJy at 3.3, 4.7, 12, and 23µm. The facility carries a 40 cm telescope providing a resolution of 7" (12" at 23 µm) with a 47 arcmin instantaneous field of view. The operating temperatures will be 32K for the 3.3 and 4.7 µm detectors, 7.8K for the 12 and 23 µm detectors and 17K for the optical system, achieved with a two stage solid hydrogen cryostat providing a lifetime of ≥7 months allowing for a single full coverage of the entire sky (see Figure 1). The instrument takes images continuously every 11 sec, while the spacecraft maintains a continuous pitch rate that matches the orbit pitch. A scan mechanism freezes the sky on the arrays. WISE will be launched by a Delta 7320-10 rocket in June, 2009.

WISE Science: With a sensitive all-sky survey in four bands, WISE is optimized to achieve its two primary science goals, which are to

- Identify the most luminous galaxies in the universe; and
- Measure the space density, mass function, and formation history of brown dwarf (BD) stars in the solar neighborhood, including the closest "stars" to the Sun.

In addition, WISE will address other fundamental topics in astrophysics, including

- Determining the radiometric albedos for almost all known asteroids (>>100,000);
- Measuring the very faint end of the luminosity function of protostars in nearby star formation regions
- Contributing to the understanding of the evolution of circumstellar disks

Table 1 summarizes the basic scientific requirements for the WISE mission.

Requirement	**Implementation**
Band 1 bandpass	2.8 – 3.8 µm
Band 2 bandpass	4.1 – 5.2 µm
Band 3 bandpass	7.5 – 16.5 µm
Band 4 bandpass	20 – 26 µm
Number of repeat observations at each point in sky	At least 4 independent exposures in each filter over at least 95% of the sky
SNR = 5 Sensitivity	0.12/0.16/0.65/2.6 mJy in bands 1, 2, 3, 4 assuming 8 repeats
Reliability	> 99.9% for SNR > 20
Completeness	> 95% for SNR > 20
Photometric accuracy	<7% relative photometric accuracy for SNR > 100
Astrometric accuracy	Position error <0.5" with respect to 2MASS for SNR > 20
Public data release	Image atlas and catalog publicly available within 17 months of end of data collection

Table 1. WISE science requirements.

WISE and Brown Dwarfs: A major goal for WISE is to identify old, low mass brown dwarfs (BDs): those which will be nearest to the Sun. The distinctive signature of such cool brown dwarfs is their strong methane absorption at 3.3 µm. The 3.3 µm channel (band 1) has been optimized to detect the methane absorption feature in BD atmospheres with T < 1000 K. [3] The 4.7 µm channel (band 2) is optimized to provide maximum contrast with the 3.3 µm channel by centering on the nearby continuum feature in BDs (see Figure 2). The expected flux at 4.7 µm from a 200 K BD at 1.3 parsec (the distance to Proxima Centauri) is 0.22 mJy, enabling a 7 sigma detection and construction of a 5 sigma color limit given a 3.3 µm limit at 7 sigma. WISE's sensitivity will enable us to find and census the population of BDs with T < 1000K. Table 2 gives the projected numbers of BDs WISE will detect for various sample mass functions, assuming a uniform star formation rate over the past 10 Gyr and that WISE just meets its 4.7 µm sensitivity requirement.

Mass Function	T_{eff} < 300	T_{eff} < 500	T_{eff} < 750	d < 1.3 pc
Chabrier et al log-normal	7	221	1340	0.88
Reid et al $M^{-0.7}$	5	121	671	0.53
Reid et al $M^{-1.0}$	11	197	921	0.93
Reid et al $M^{-1.3}$	22	330	1310	1.74

Table 2: Projected number of BDs detectable by WISE for various mass functions. [4], [5]

As shown in the table, the number of cold BDs detected by WISE will strongly constrain the mass function.

Brown dwarfs hosting planets. The recently discovered planetary mass companion to the nearby BD 2M1207 [6], which was discovered in the 2MASS survey, is 8 Myr old and 70 pc distant. If we consider instead an 8 Gyr old BD primary, the space density of these objects should be 1000x higher. WISE should see several out to 11 pc, and JWST could see their secondaries. Thus, WISE will find brown dwarf hosts of planetary systems.

WISE and Asteroids: Asteroids are much brighter in the mid-IR than in the visible (see Figure 2). Also, mid-IR observations allow a much more precise measurement of the asteroid's diameter to be made. WISE will measure diameters of 1 km main belt asteroids (MBAs) and 200 m near-Earth objects (NEOs). WISE will identify >>100,000 asteroids by observing them move in the hours between frames. WISE will be especially powerful for detecting dark NEOs and Atens, the objects most likely to present an impact hazard. On average, WISE will see several asteroids per frame.

WISE and Debris Disks: WISE will observe all nearby G stars. The "Hale Bopp" star, HD 69830 [7], was one out of 85 observed by Spitzer. This unusual star has a spectrum that matches almost exactly that of comet Hale Bopp, allowing us to infer that the star possesses a zodiacal disk filled with cometary material. As WISE will measure the 23 µm excesses of all nearby stars, we estimate that WISE will see ~2000 stars with excesses similar to that of the Hale Bopp star.

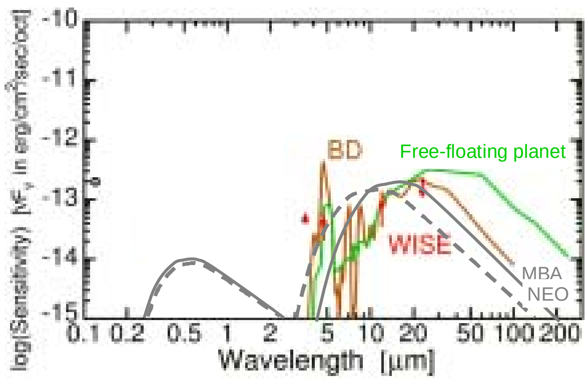

Figure 2: WISE sensitivity vs. wavelength.

The WISE Team: WISE is a joint project of the University of California, Los Angeles, and the Jet Propulsion Laboratory/California Institute of Technology, funded by the National Aeronautics and Space Administration. The WISE science team includes N. Wright (PI), P. Eisenhardt (Project Scientist), A. Mainzer (Deputy Project Scientist), A. Blain, M. Cohen, N. Craig (Education/Public Outreach Lead), R. Cutri (Data Processing Lead), N. Gautier, T. Jarrett, D. Kirkpatrick, D. Leisawitz (Mission Scientist), C. Lonsdale, J. Mather, I. McLean, R. McMillan, D. Padgett, M. Ressler, M. Skrutskie, A. Stanford, and R. Walker. The WISE payload is being built by the Space Dynamics Lab, with the spacecraft provided by Ball Aerospace. Data reduction will be performed by the Infrared Processing and Analysis Center at Caltech.

References: [1] Mainzer, A., et al. (2005) *Proc. SPIE, 5899.* [2] Duval, V., et al. (2004) *Proc. SPIE., 5847,* 101. [3] Mainzer, A., et al. (2005) *AJ, submitted.* [4] Chabrier, G. (2003) *PASP, 115,* 763. [5] Reid, I., et al. (1999) *ApJ, 521,* 613. [6] Chauvin, G., et al.. (2005) *A&A, accepted.* [7] Beichman, et al. (2005) *astro-ph/0504491*