Prospects of brown dwarf and exoplanet research

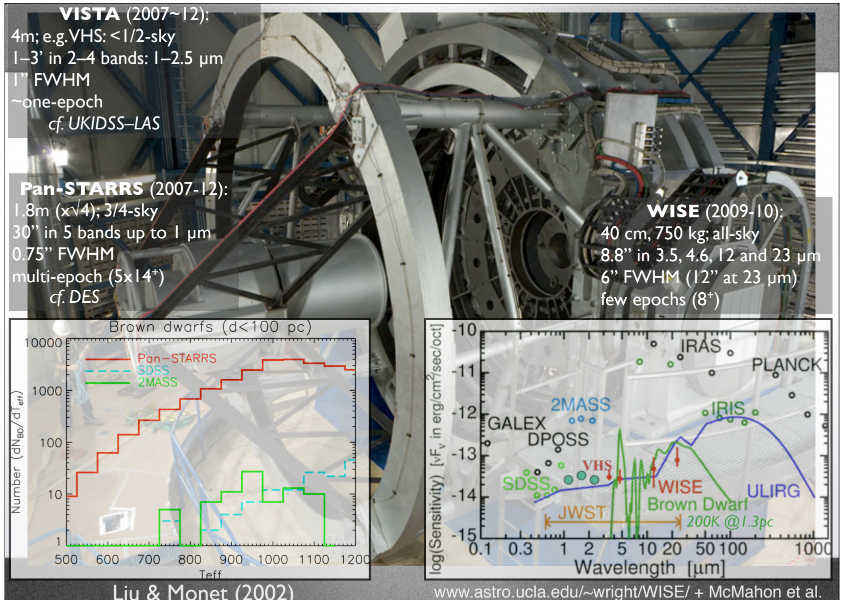
February 5, 2007

Brown dwarfs

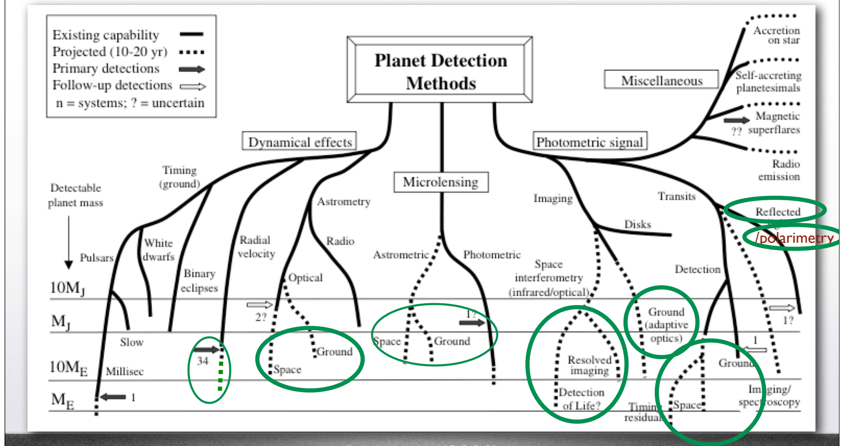
- Theory:
  - Atmospheres:
    - 3-D code, time-dependent problems
    - low-metallicity
    - classification
    - Y class modelisation
  - Structure:
    - young objects (input from accretion and disk modelling)
    - irradiated objects
  - Formation

Brown dwarfs

- Observations:
  - Large scale surveys:
    - New nearby extremely cold objects (Y dwarfs)
    - Larger statistics of field L and T dwarfs, rare L and T dwarfs
    - Star forming regions: [2-] Jupiter-mass objects, spatial distribution,…
  - High resolution imaging and spectroscopy:
    - Dynamical masses of more binaries
    - Better accuracy in binary ratio, mass distribution,...



Exoplanets

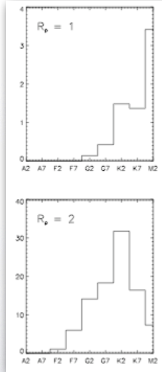


Perryman (2000)

Transits

Corot

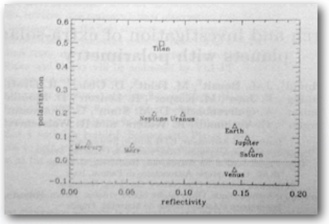
- Many ground based projects:
  - improved time-coverage through world networks
  - larger cameras (e.g. Pan-STARRS)
- Space projects:
  - Corot: 63M€, 7.0°^{2}/2, 5x180d
  - Kepler: 100°^{2}, 3.7”-pixels, 10”-FWHM, 100 Mpixels, 200 3s-exposure stack, 10^5 stars



Solar variability, one planet/star

Bordé et al. (2003)

High precision polarimetry



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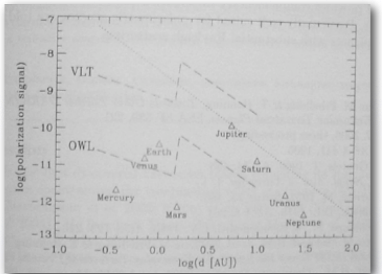
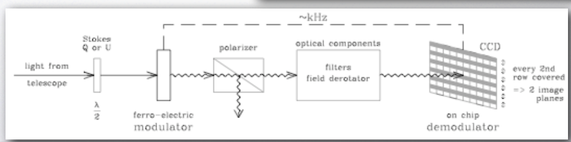




Schmid et al. (2005)

Extreme AO

Example: ESO’s SPHERE (LAOG, MPIA et al.)

Requirement	IRDIS	IFS	ZIMPOL
Optical Throughput	40% (goal 45%) for each beam	60% (goal 70%)	25% (goal 40%)
Wavelength coverage	0.95-2.320μm	0.95-1.35μm	600-900nm (goal: 500-900nm)
Spectral Resolution	DBI: R ~ 20-30 LS: R ~ 50 (Y-K), 500 (0.95-1.8μm)	R ~ 30	-
Field of View	>11" square (goal 12.5" square)	>1.35" square (goal 3" square)	>3" square
Spatial Sampling	12.25 mas (λ/2D at 0.95μm)	12.25 mas (λ/2D at 0.95μm)	<7.8 mas (λ/2D at 600nm)
Contrast (5σ)	at 0.1": 5e-5 (goal 1e-5) at 0.5": 5e-6 (goal 5e-7)	at 0.5": < 1e-6 (goal 1e-8)	at 1": < 1e-8 in 4hr (goal 3e-9 in 15 hr) for a 30% polarized planet
Observing modes	Imaging, dual-band imaging (DBI), dual-polarimetric imaging (DPI), long-slit spectroscopy (LS)	IFS	Visible Imaging Differential polarimetric Imaging

SPHERE ESO web page

NWO

The New Worlds Observer

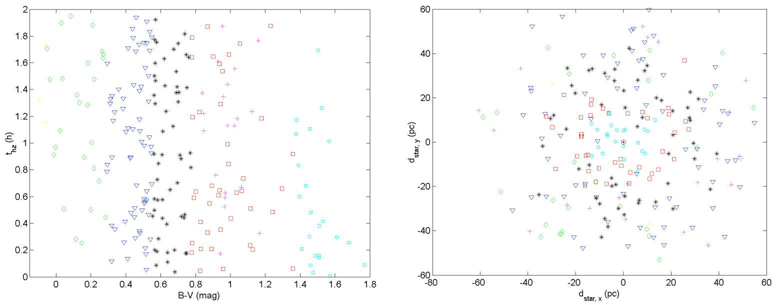
Cash, Nature 2006

CESO

The Celestial Exoplanet Survey Occulter

Janson, PASP accepted

Example



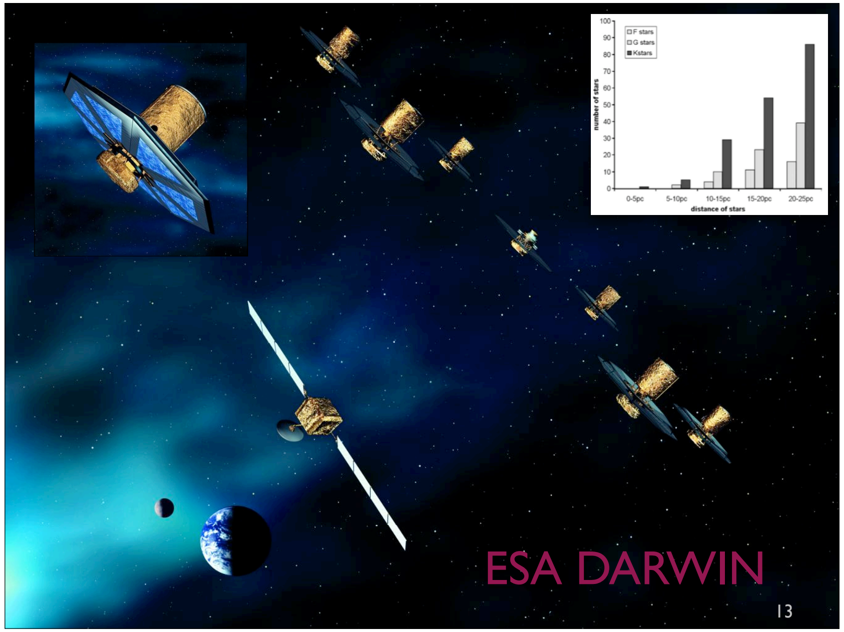
Advantages: Cheap(er), bigger telescopes, more complex instrumentation

Space interferometry (I) nulling

The 20-foot beam on top of the 100-inch Hooker Telescope on Mt. Wilson in Southern California.

27 h, 1 μm, Solar system @ 10 pc

Guyon & Roddier (2002)



µas astrometry

Ground interferometers

- Principles:

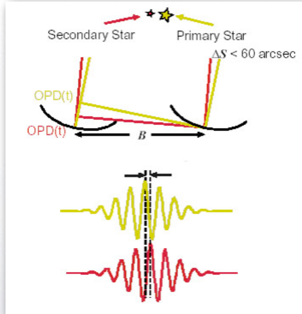
$$\text{OPD bright} = \alpha * B + \phi 1 + A1 + L1$$

$$\text{OPD bright - OPD faint} = \Delta OPD = \Delta S * B + \phi + \Delta A + \Delta L$$

- Atmospheric problems:

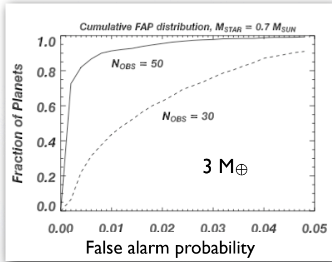
filled aperture: $\varepsilon_\theta \propto \theta^{1/3}$

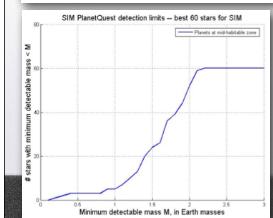
interferometer: $\varepsilon_\theta \propto B^{-2/3}\theta$



www.eso.org/projects/vlti/instru/prima/index_prima.html

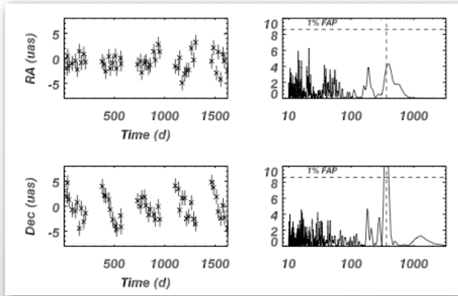
Space interferometry (2) SIM





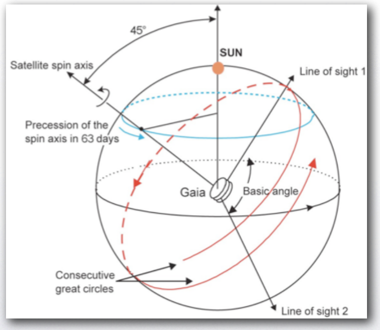
SIM project summaries (2004)

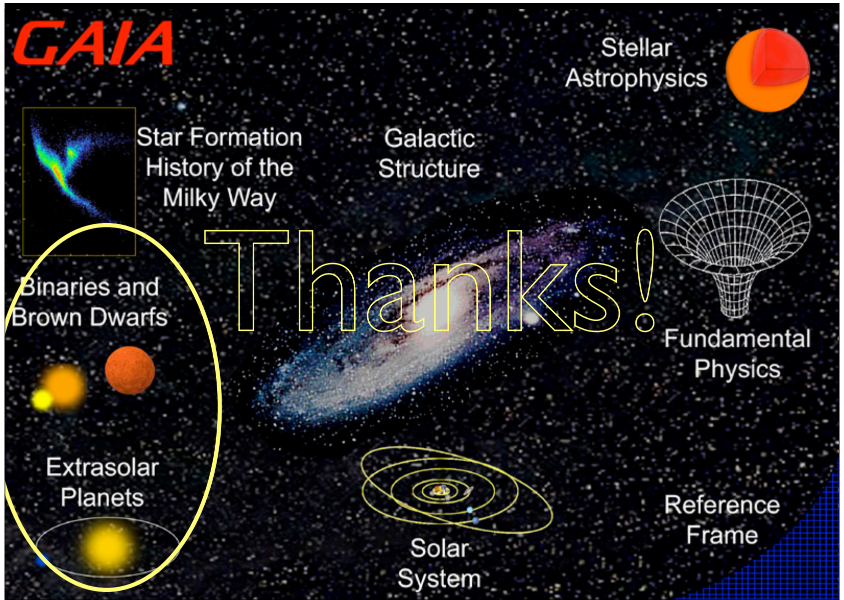
3-M⊕ planet orbiting at 1 AU from a 0.7-M⊙ star, at 5 pc
50 measurements



Marcy et al. (2005) *PThPhSuppl.* **158**

GAIA




GAIA
Stellar Astrophysics
Star Formation History of the Milky Way
Galactic Structure
Thanks!
Binaries and Brown Dwarfs
Fundamental Physics
Extrasolar Planets
Reference Frame
Solar System