# Near-Infrared Astronomy and Data Reduction

Mischa Schirmer[1,2]

[1]Argelander-Institute for Astronomy, University of Bonn, Germany

[2]Isaac Newton Group of Telesopes, La Palma, Spain

Central European Deepsky Imaging Conference (2009)



# Outline

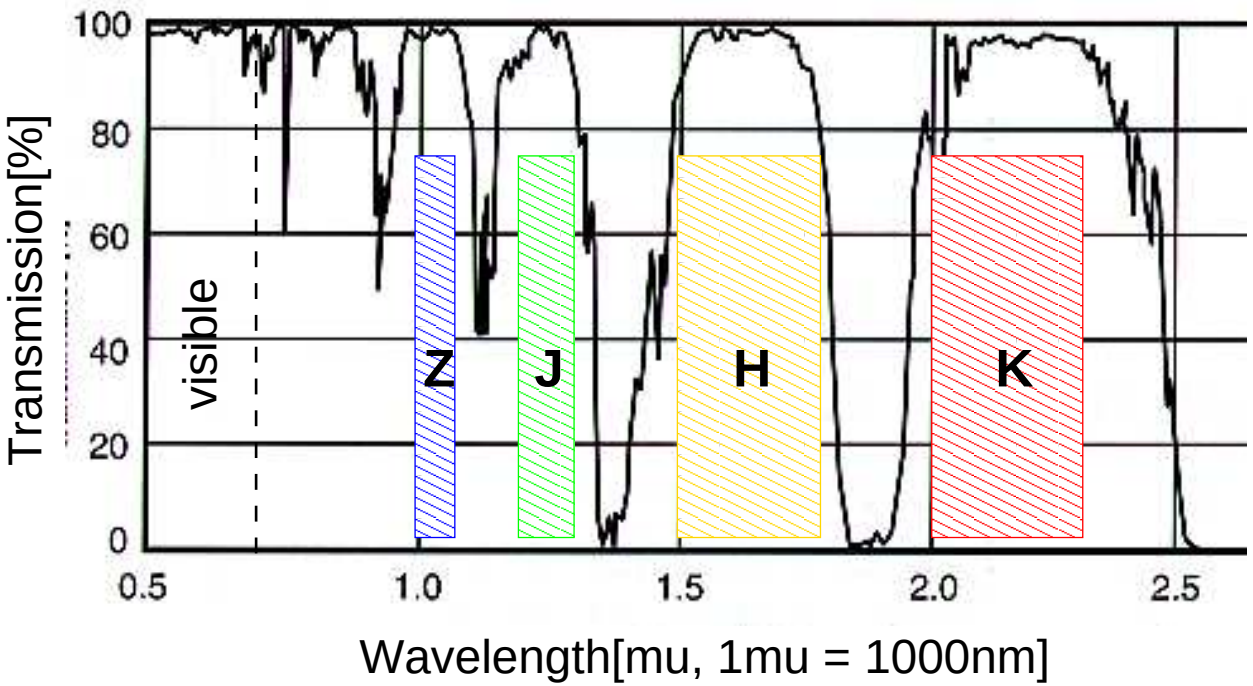
# Section 1: Observing in the Near-Infrared

## Overview

- Atmospheric transmission windows, JHK filters
- 3 examples why we observe in the near-IR
  - dusty stuff
  - cool stuff
  - distant stuff

# Transmission windows in the near-IR

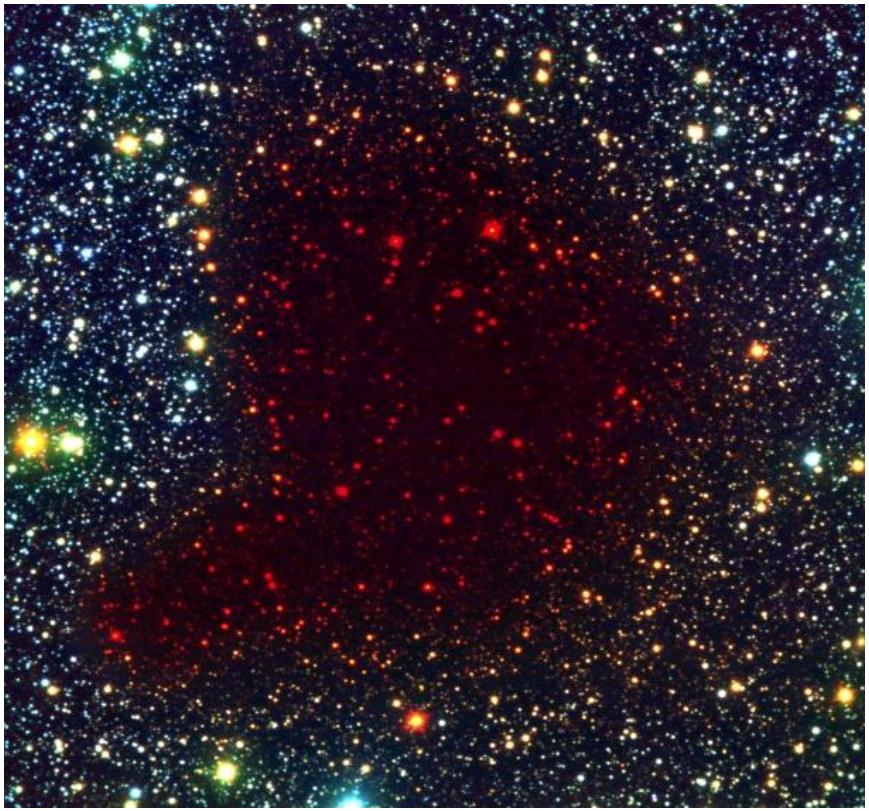
- Commonly used filters: Z, J, H, K(s)
- Cover the stable parts of the transmissive windows
- Absorption caused by water vapour and $CO_2$



# Near-IR wavelenghts can penetrate dust

B68 molecular cloud (VLT *FORS* and *ISAAC*)

BVI

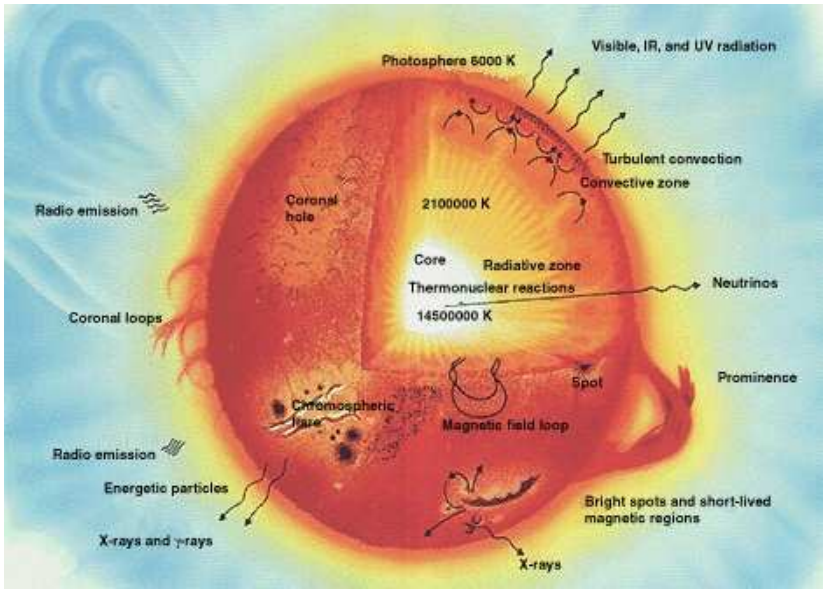


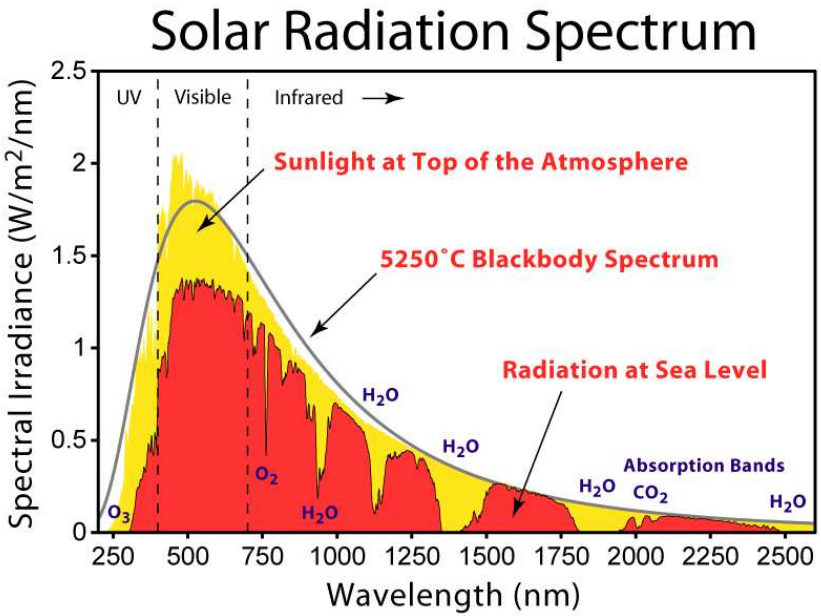
BIK

# Cool things become visible only in the near-IR

## Normal solar-type stars visible in the optical

- hydrogen burning
- layered, not fully convective like a BD
- $T_{eff} \sim$ 5000K, maximum emission between 400nm - 700nm

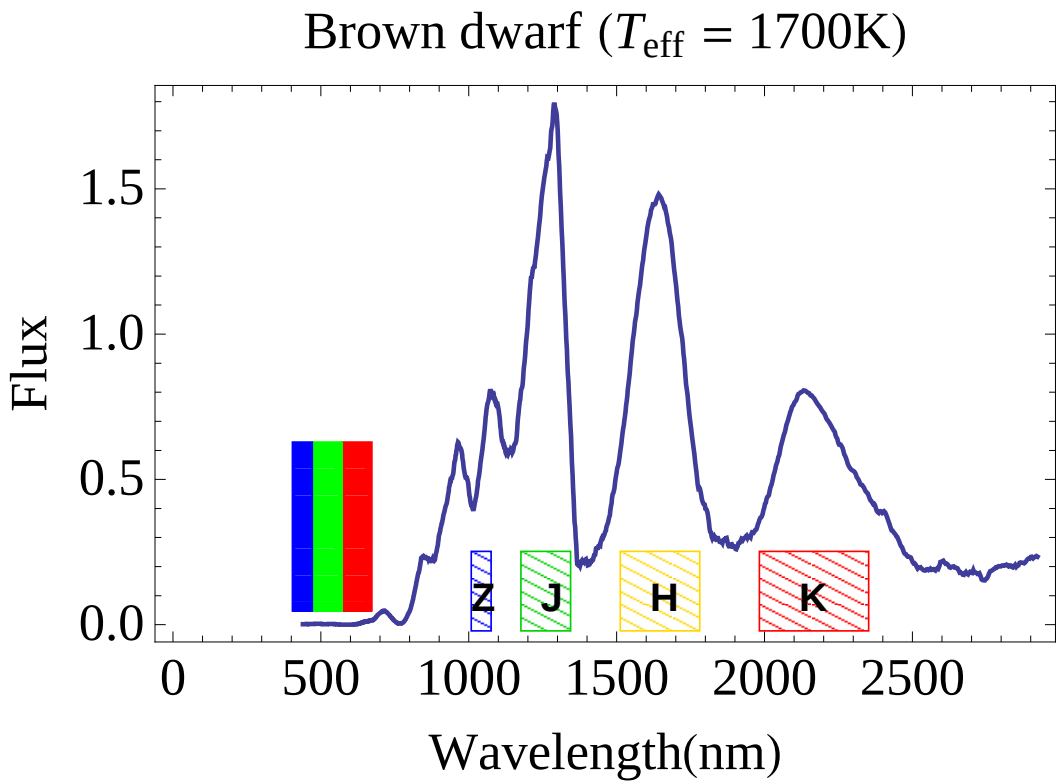


# Cool things become visible only in the near-IR

## Brown dwarfs visible in the near-IR

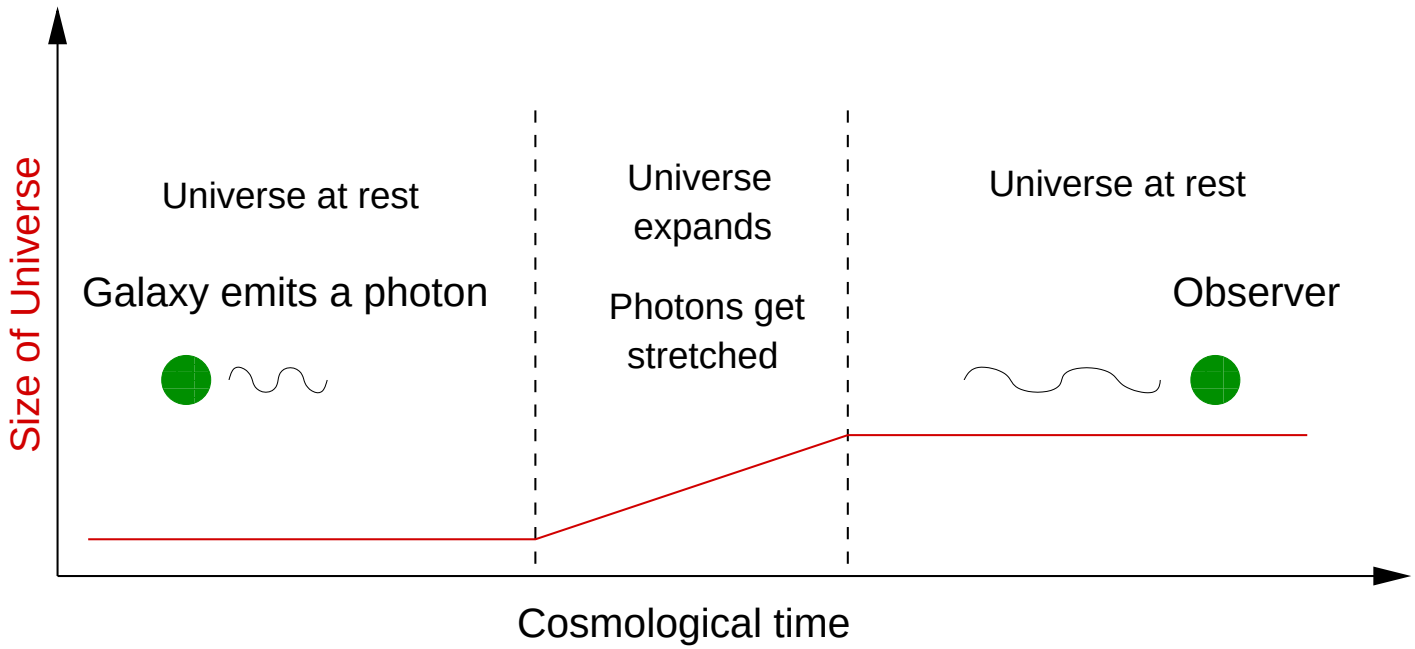
- no stars: BDs do not burn hydrogen ( $< 0.012\ M_{Sun}$)
- no planets: BDs do burn Deuterium and Lithium ( $> 13\ M_{Jupiter}$)



# Very distant objects are only visible in the near-IR

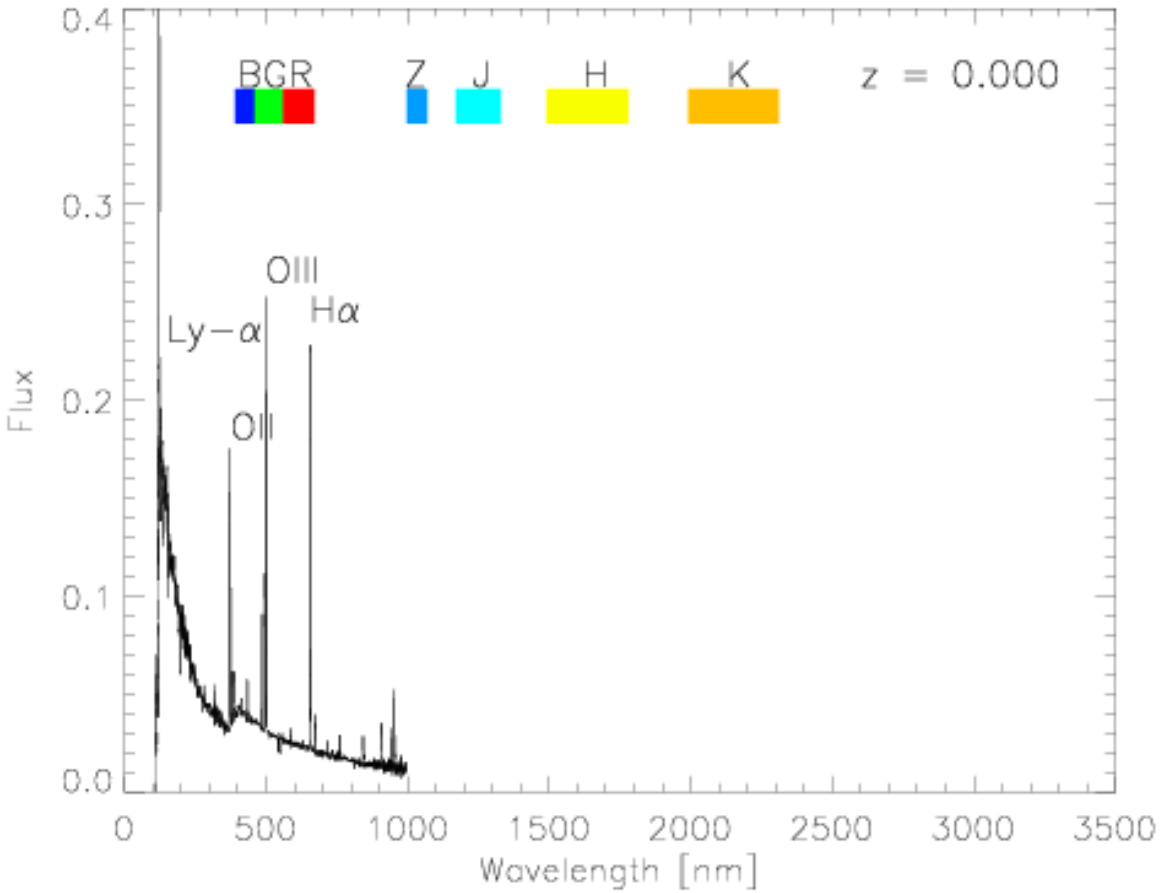
Cosmological redshift $z$ (is no doppler effect):

- Expansion of the Universe = stretching of wavelengths
- z=1: universe at 1/2 size when photon emitted
- z=5: universe at 1/6 size when photon emitted, etc...



# Very distant objects are only visible in the near-IR

Effect of cosmological redshift on a galaxy spectrum:

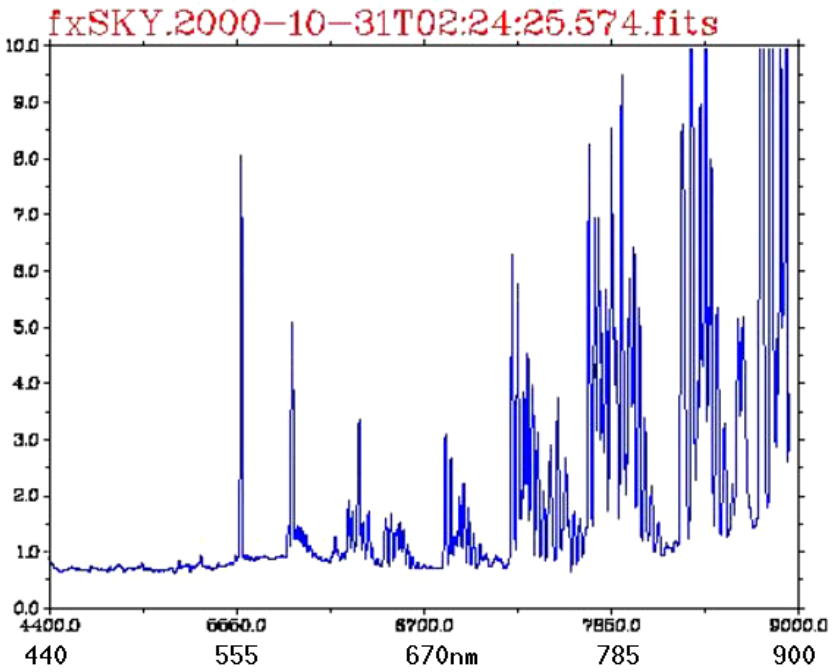


# Section 2:
# Why observing in the near-IR is difficult...

## Overview

- See an optical airglow movie...
- See a near-IR airglow movie...
- Typical near-IR detectors
- Nasty things near-IR detectors do to us astronomers

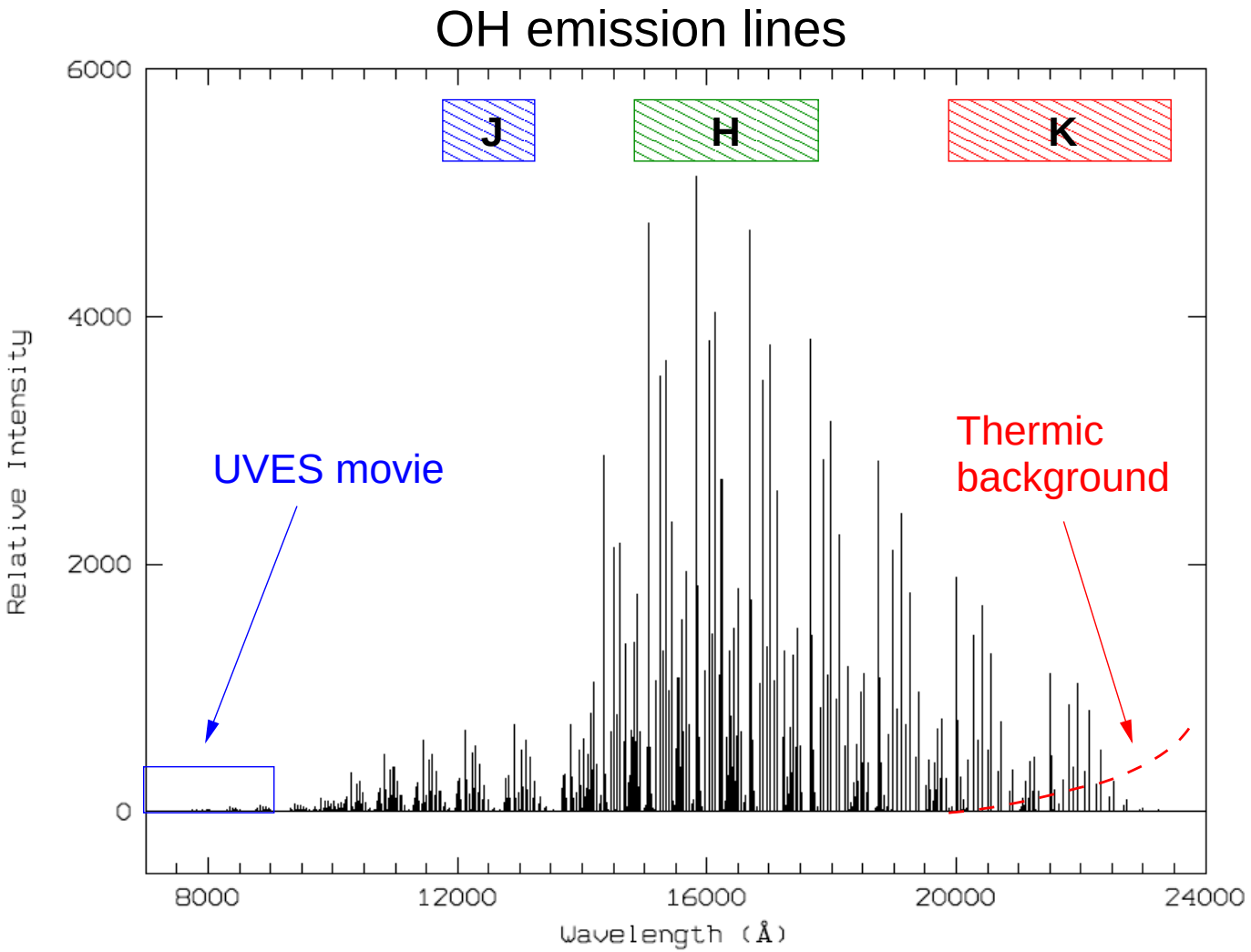
# Optical airglow




Movie: 4 years of optical

*UVES* spectra (VLT, Fernando Patat)

# Near-infrared airglow



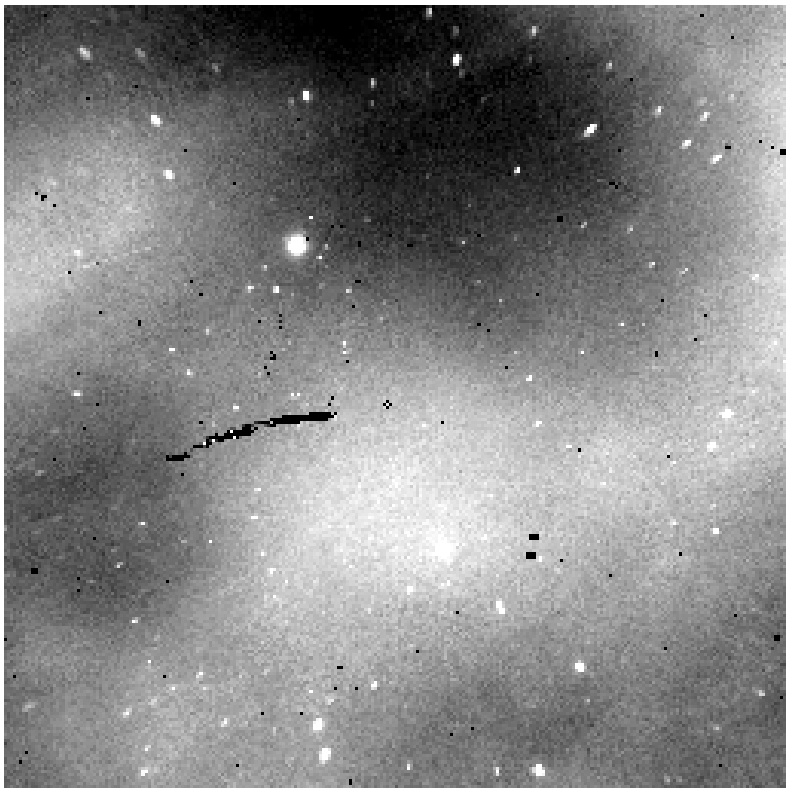

Night sky brightness:
[mag / arcsec$^2$]

$$\begin{aligned} B &= 22.7 \\ V &= 21.9 \\ R &= 21.0 \\ I &= 20.0 \\ J &= 16.0 \\ H &= 14.5 \\ K &= 13.5 \end{aligned}$$

Short exposure times:
30, 20, 10s in J, H, K

# Near-infrared airglow

Movie: 1.5 hours of airglow in H-band

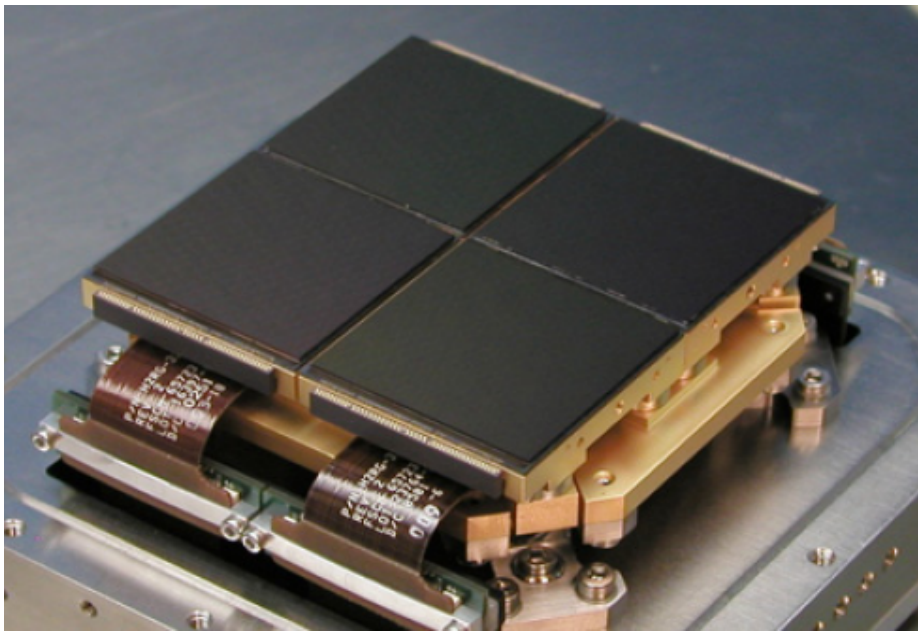


Wide-field airglow experiment for the 2-Micron All-Sky Survey (2MASS)

- Individual exposure time: 15s
- Field of view: 9 degrees
- 1s movie = 7 min real time
- Variation: 10% around mean
- Mean level already removed!

# Near-infrared instruments

- Usually 1k×1k or 2k×2k HgCdTe detectors
- About 90% quantum efficiency from Z to K
- Operating temperature: 65-75 K
- Liquid nitrogen and helium cooling
- Very sensitive



Left: HAWK-I detector mosaic at the VLT
4 $2k \times 2k$ detectors
Pixel scale: 0.106 arcsec
Field of view: 7.5 arcmin

# Near-infrared instruments

HAWK-I at the Nasmyth focus of Yepun (VLT No. 4)

# Strange effects (I): Reset anomaly

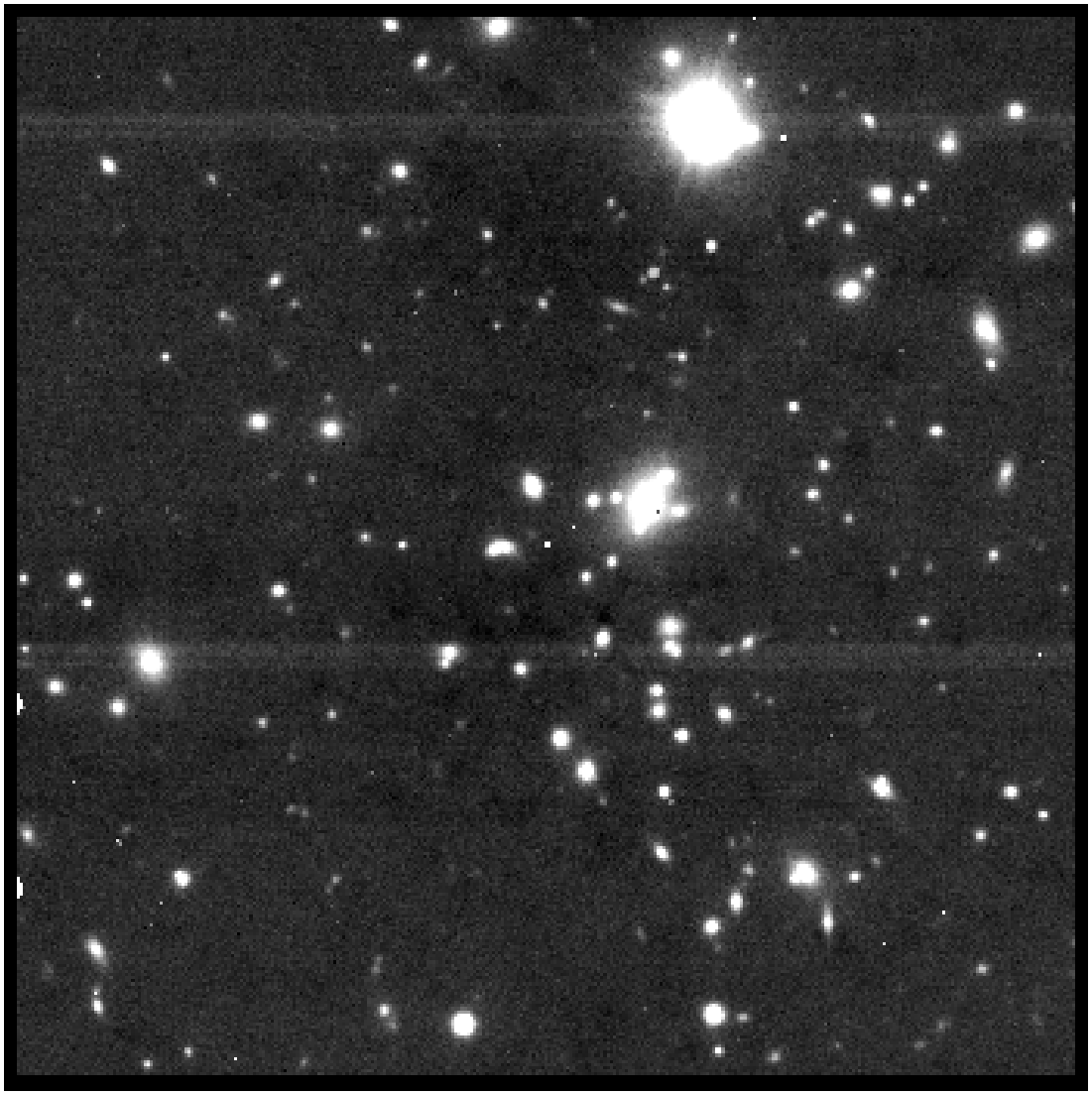
Two detector states:

- *resetting*
- *exposing*

Anomaly depends on:

- detector temperature
- exposure time
- illumination level
- exposure number
- erratic component

# Strange effects (II): Cross-talk



Left: *row crosstalk*

Not shown:
*normal crosstalk*
(ghost images in the readout quadrants)

Cause: electromagnetic coupling of the read-outs, through air or through the detector itself

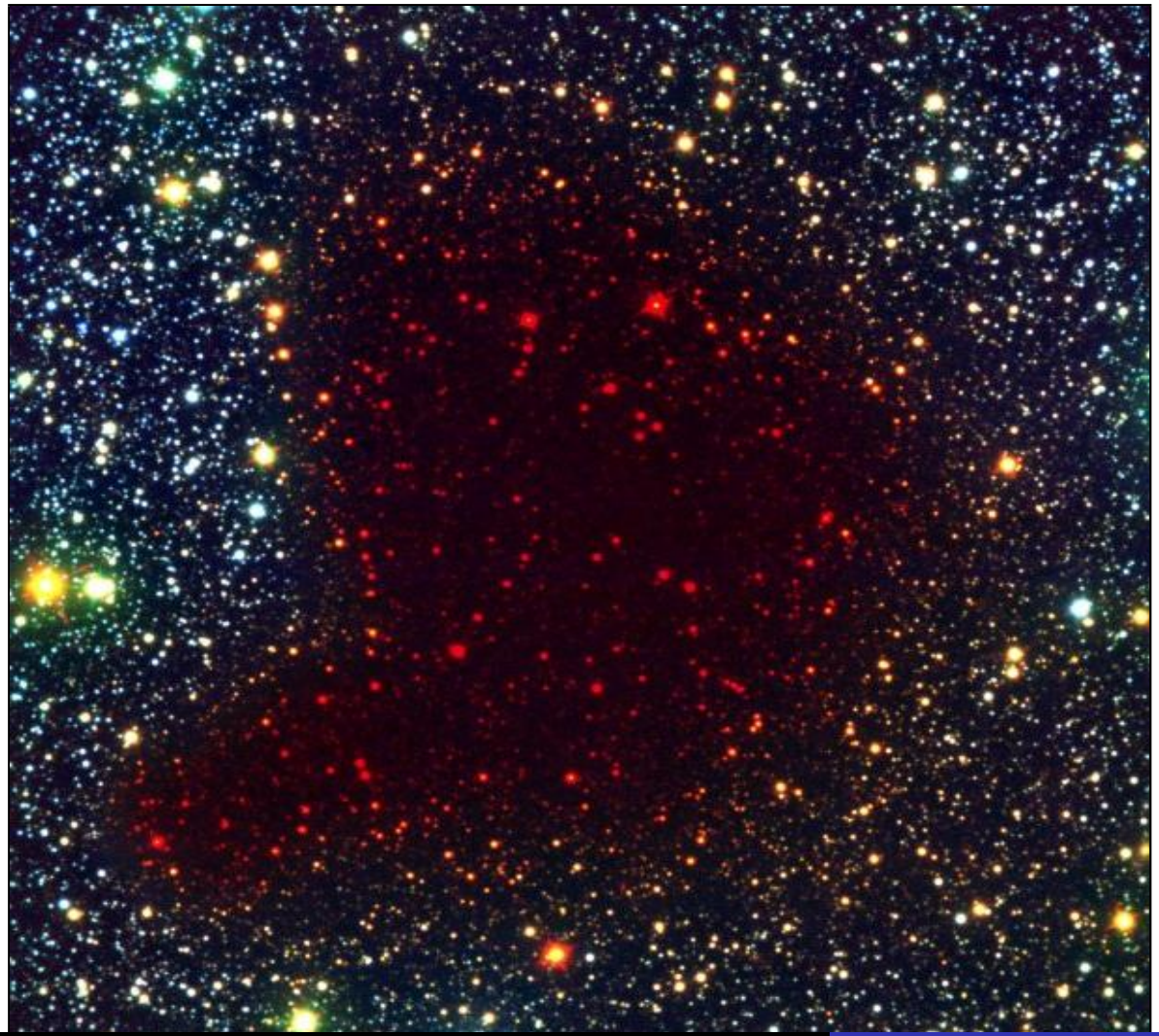
# Data reduction flow in *THELI*

## Section 3: Reducing near-IR images

Overview of a full reduction process (similar to optical):

- Reformat FITS headers
- Create master BIAS/DARK/FLAT
- Apply master calibrators to images
- Create and subtract sky background model
- Weighting
- Astrometry and photometry
- Coaddition

# Demo: Reducing some H-band images of the Hubble Deep Field South



# For Further Reading I

*An excellent overview of near-infrared astronomy*
http://coolcosmos.ipac.caltech.edu/cosmic_classroom/ir_tutorial/

*The 2MASS wide-field airglow experiment*
http://astsun.astro.virginia.edu/∼mfs4n/2mass/airglow/airglow.html

*The HAWK-I near-infrared imager at the VLT*
http://www.eso.org/sci/facilities/paranal/instruments/hawki/index.html