# Cosmic Infrared Background and Zodiacal light Measurements with Nano-satellite

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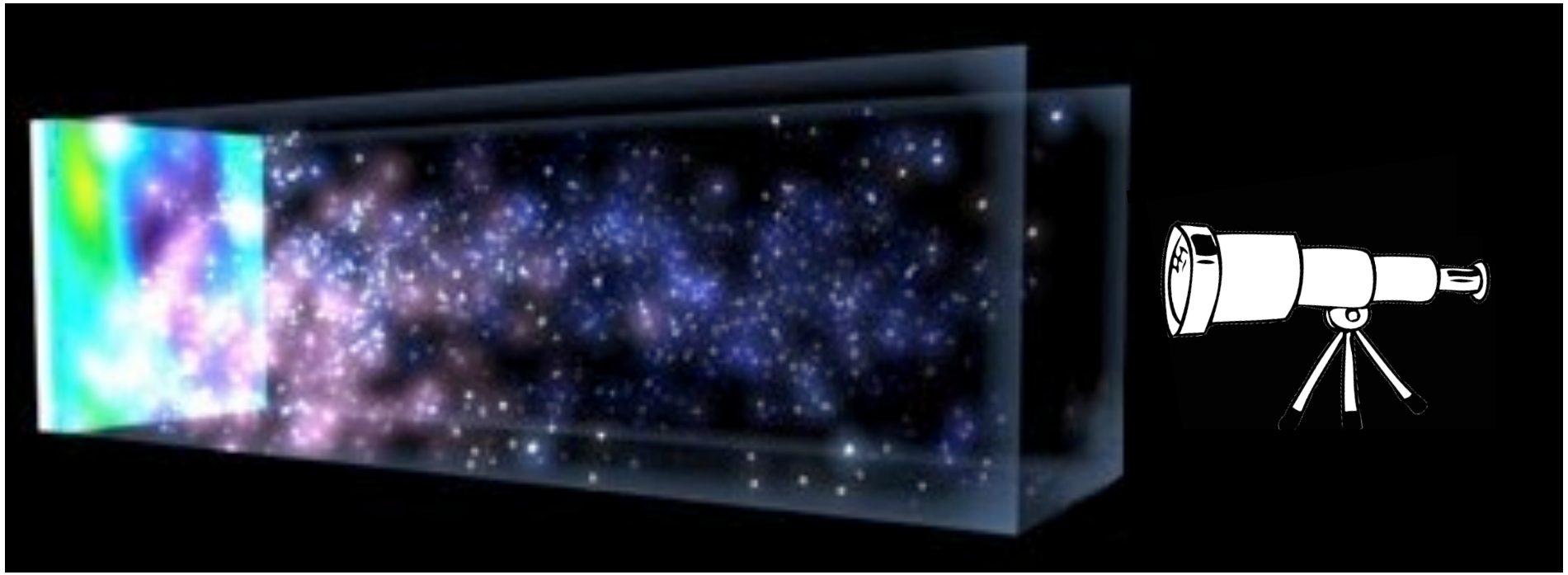
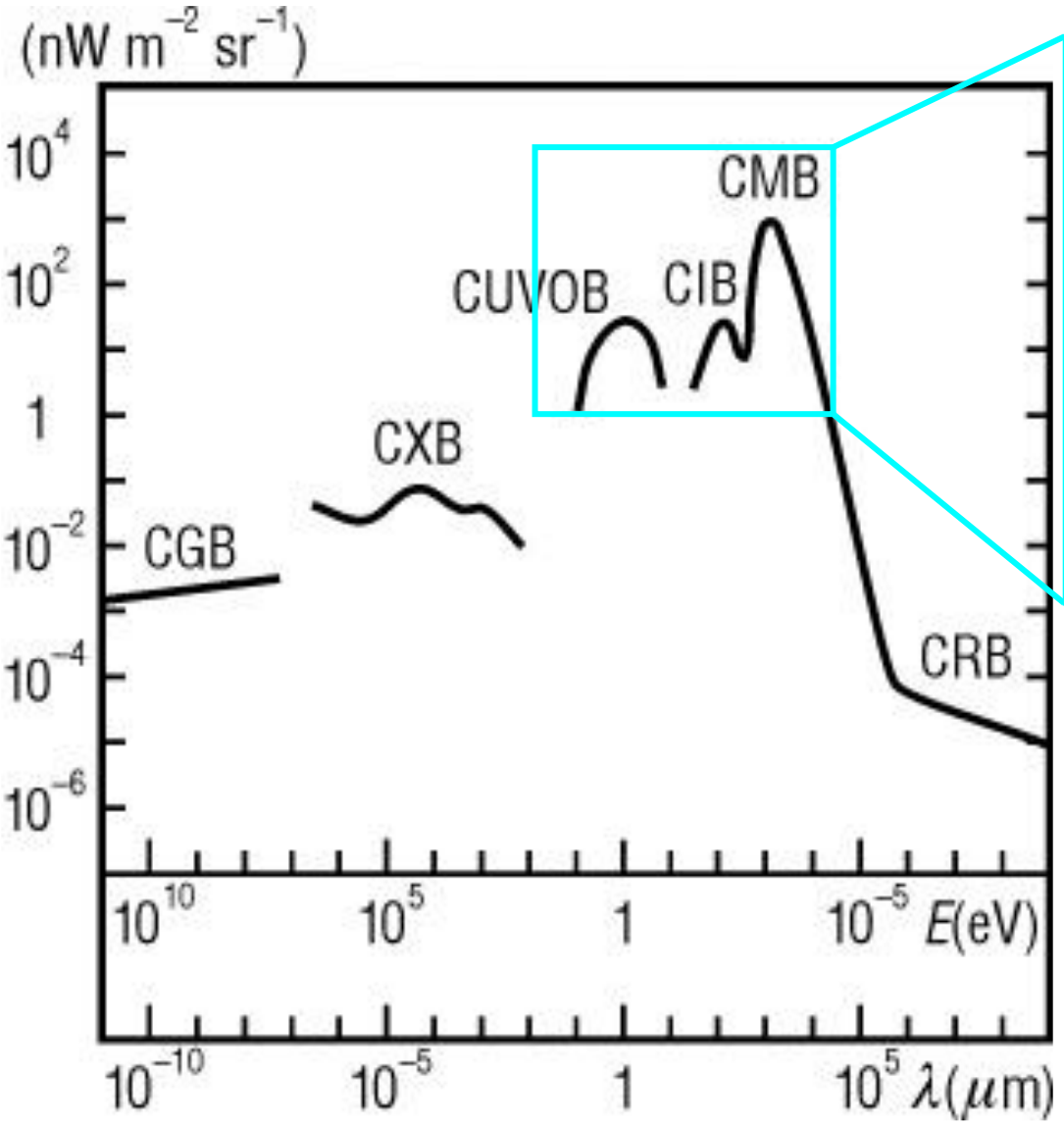
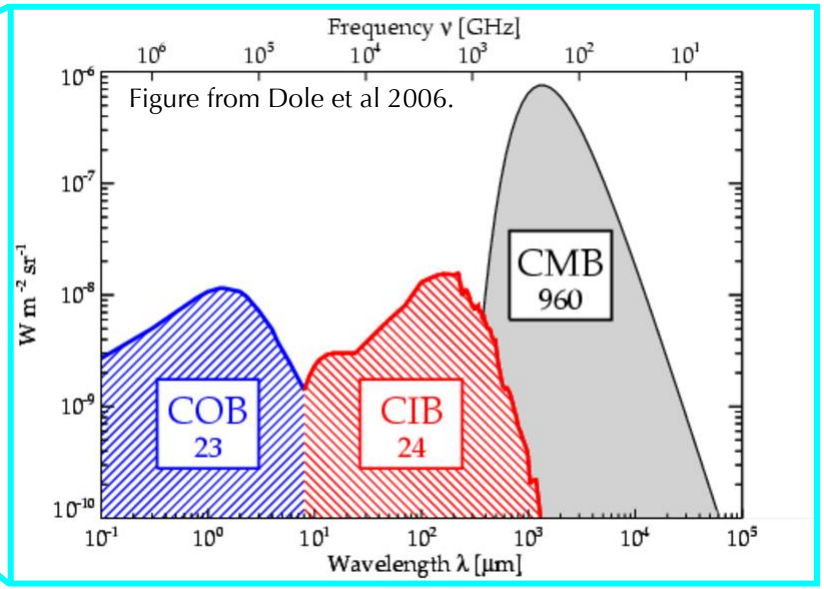
# Cosmic Background Radiation

- Cosmic Background Radiation - the integrated light along the line of sight at a given wavelength.
- Measurement of the cosmic background constrains physical processes in the Universe.



# Cosmic Infrared Background



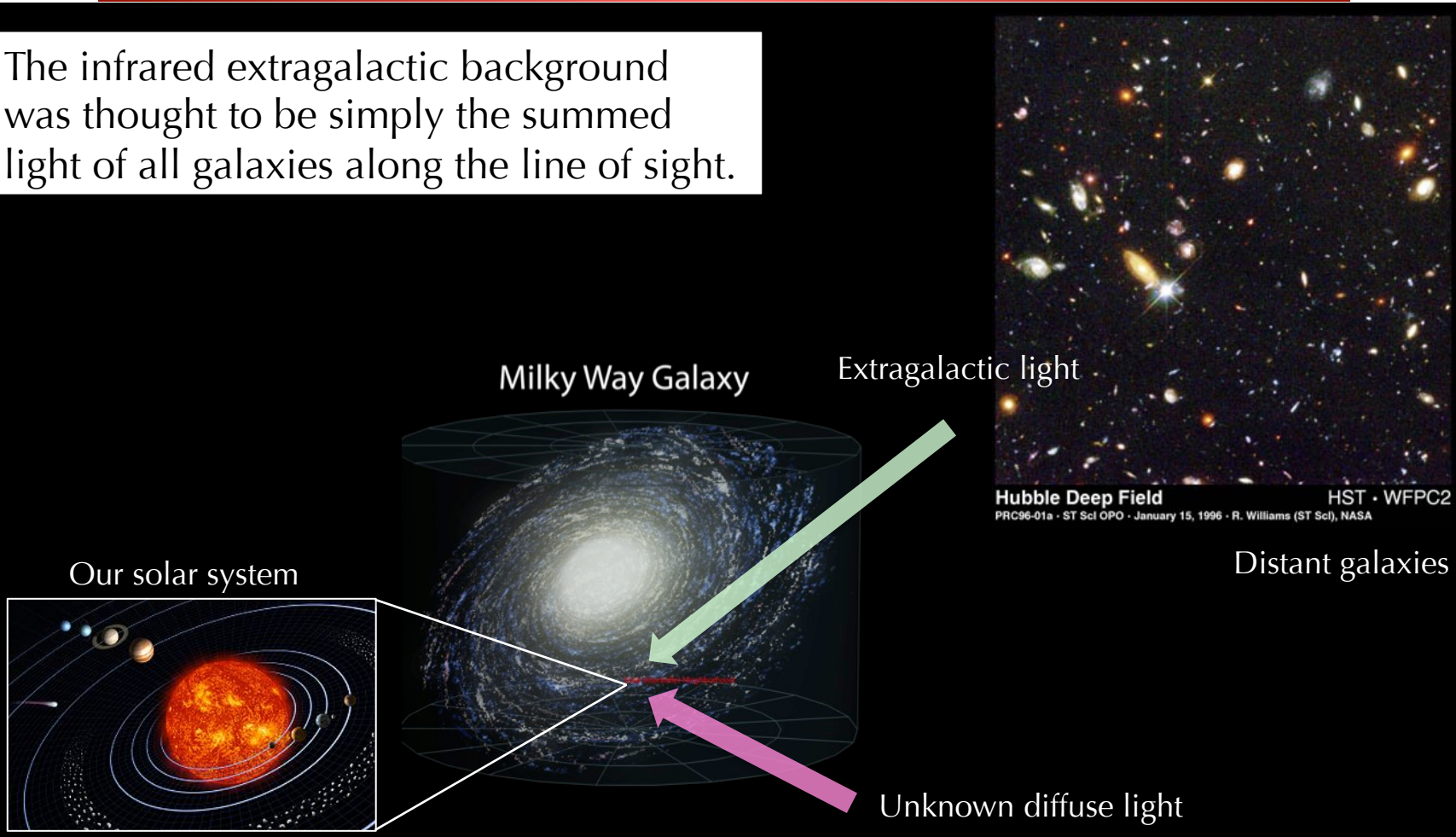




The physical mechanisms causing photon emission are different at different wavelengths.

The cosmic infrared background is known to be tied to star formation history in the universe.

# Cosmic Infrared Background

The infrared extragalactic background was thought to be simply the summed light of all galaxies along the line of sight.

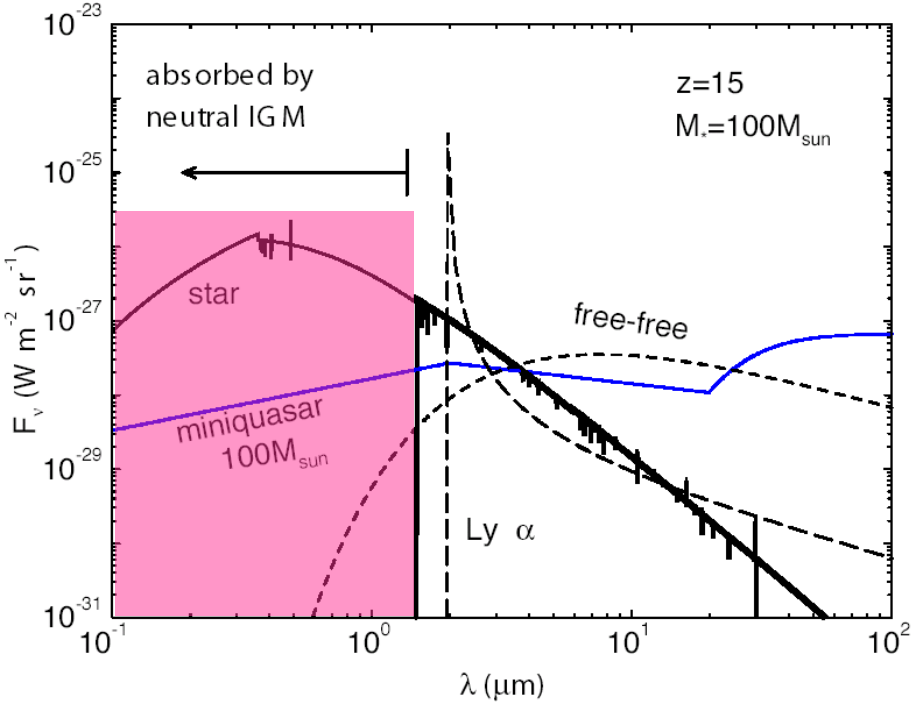


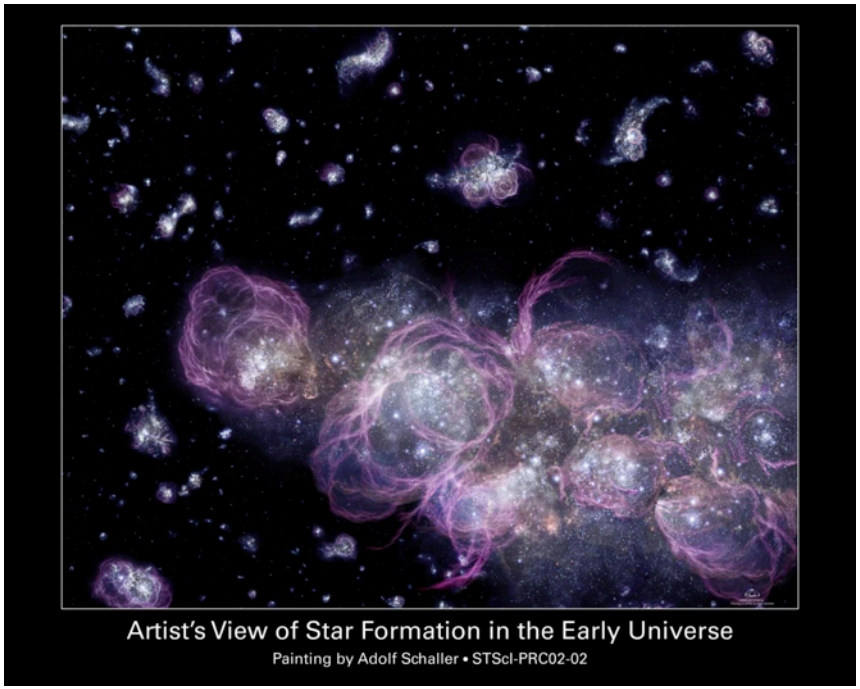

If there were a truly diffuse component, the sum of all galaxies would not equal to the total background.

# Remnant light from First Stars

- Light from First Stars is emitted in the UV and subsequently redshifted to the near-infrared today by cosmic expansion.
- Radiation spectrum would indicate sharp edge due to intergalactic absorption.

- Measuring the near-infrared background is very important for cosmology.




Cooray&Yoshida 2004 (MNRAS, 351, L71), Santos et al. 2002 (MNRAS, 336, 1082)

# Possible to see First stars individually?

- Future large-aperture telescopes in the next decade

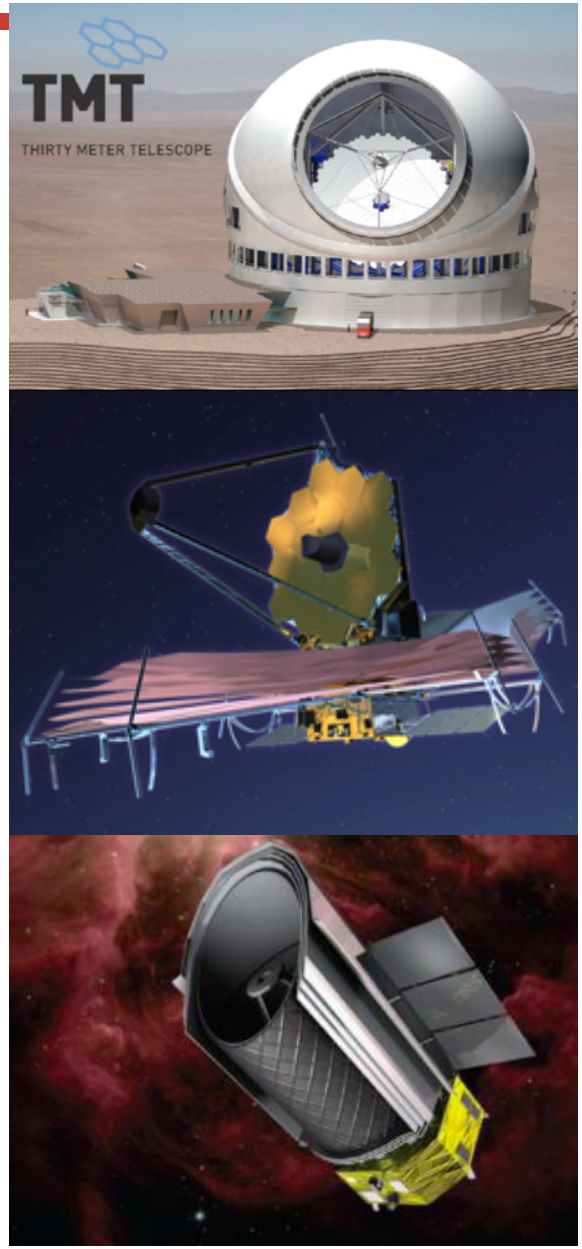
  TMT - 30m ground-based telescope

  JWST – 6m space telescope

  SPICA – 3m cooled infrared telescope

- These giants aim to observe the early universe, but First stars are individually too faint to detect.

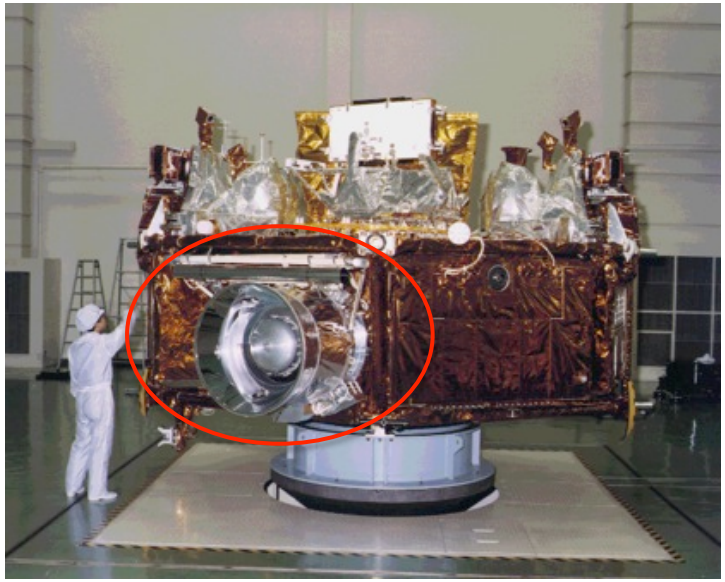
- Measuring the background radiation is a promising method to study First stars.



# Observation of the near-infrared background

- Previous measurements of the near-infrared background were carried out with space telescopes (COBE & IRTS) to avoid atmospheric emission.
- These telescopes had apertures of ~10cm and field-of-view of ~1deg.
- We can do exciting science with such a small telescope.

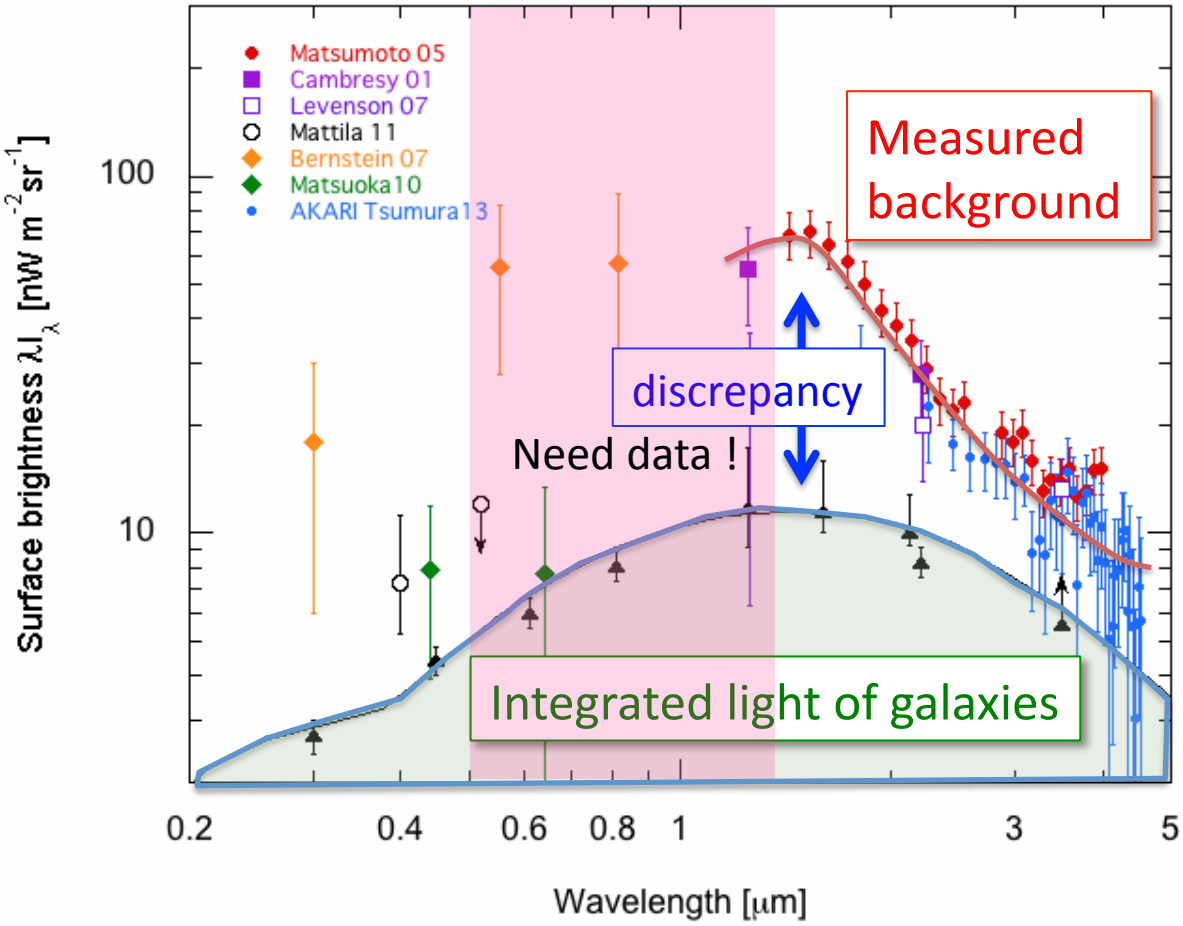

COBE (NASA)



IRTS/SFU (ISAS)

# Observed near-infrared background

- Clear discrepancy between the measured background and the expected levels of the integrated light of galaxies.
- This extra component may arise from cosmological background due to First stars and/or the other primordial objects.



# Foreground subtraction

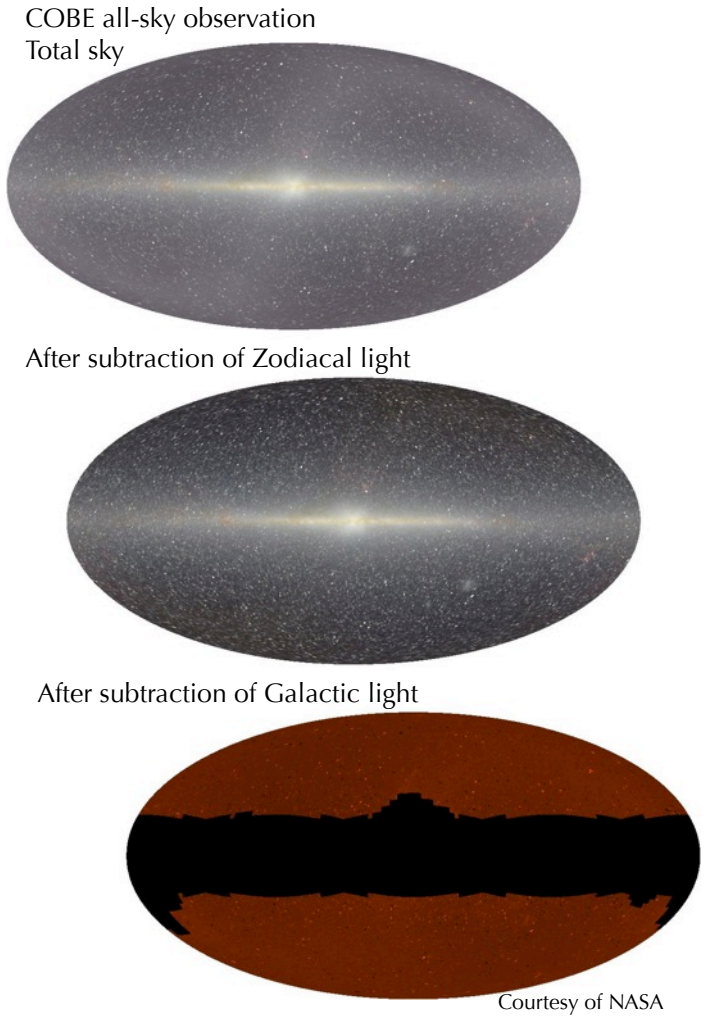
- To measure the background radiation, subtraction of the foreground radiation from the observed total brightness is necessary.

Emission components in the Near-infrared

Total sky brightness

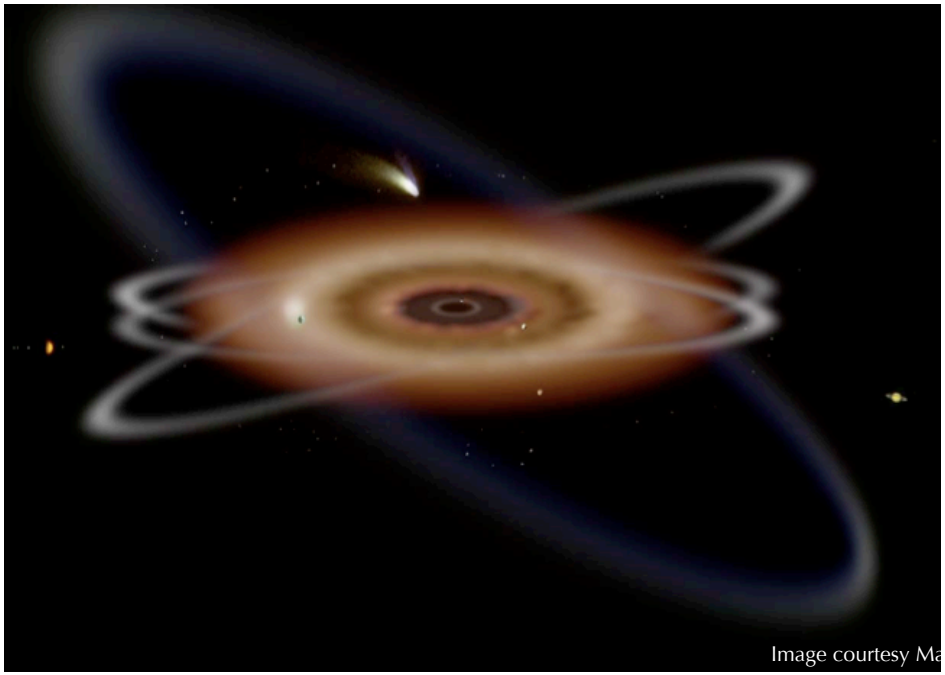
= Zodiacal light (interplanetary dust) ~90%
+ Galactic light (starlight and dust) ~5%
+ Integrated light of external galaxies ~5%
+ Cosmological background (First stars)
with unknown fraction

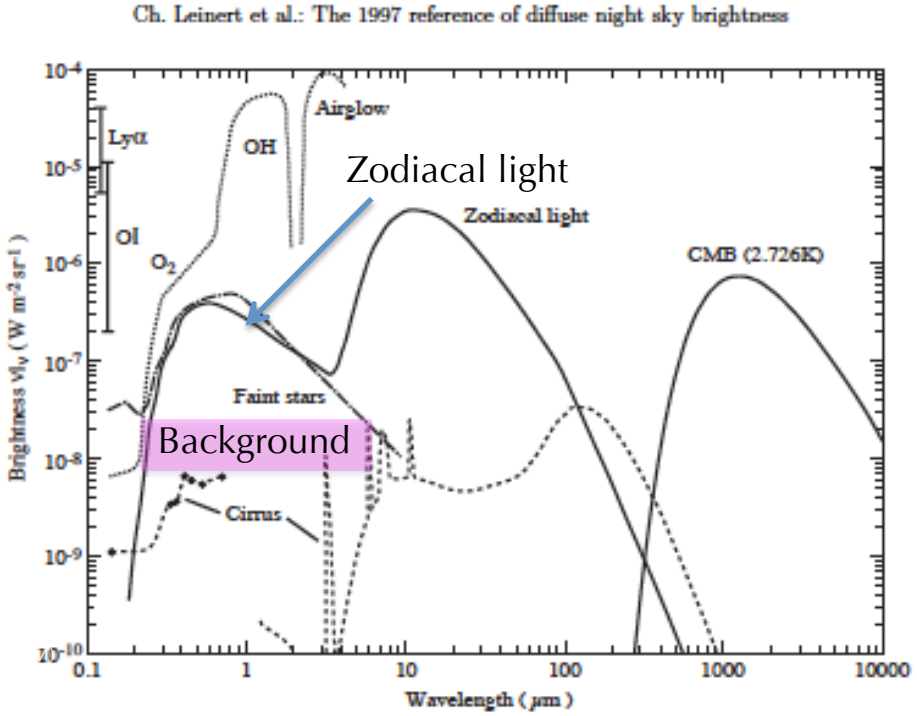
- Precise component separation of ZL is important for the background measurement.



# Zodiacal light – major foreground component

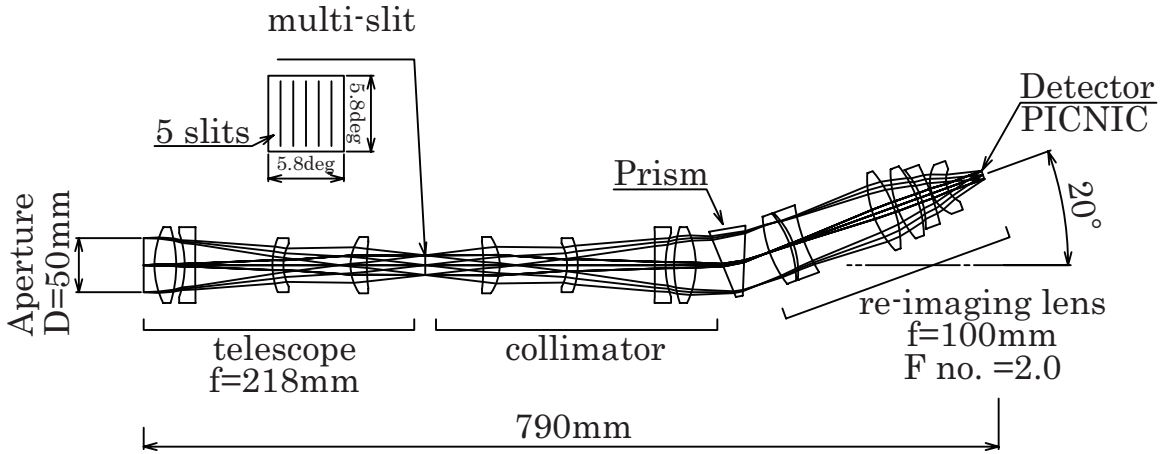
- In the visible ZL is the scattered sunlight by interplanetary dusts and has sun-like radiation spectrum
- Dust cloud has complex structure, difficult to model
- ZL provides information on structure and evolution of the solar system via distribution and composition of the dust

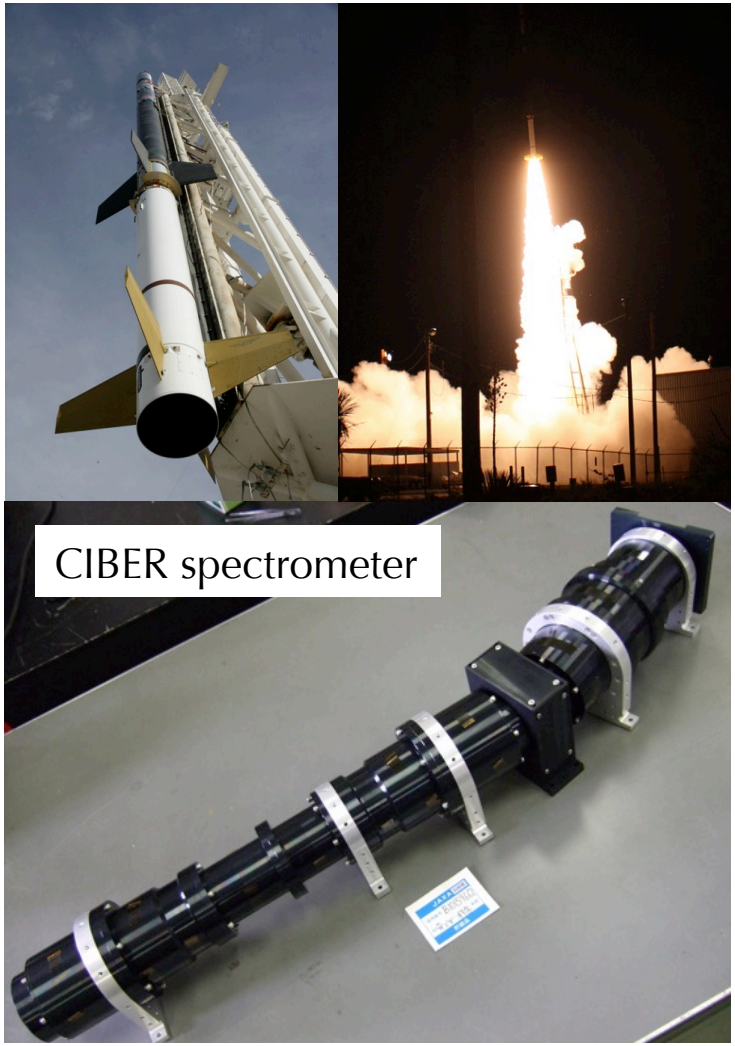


# Rocket experiment CIBER

- CIBER - Cosmic Infrared Background ExpeRiment
- Low-resolution spectrometer
  - $LN_2$-cooled 5cm telescope
  - Prism spectroscopy
  - Near-infrared wavelength (0.8-2 μm)
- Could be proto-type instrument for future missions
  - Scale-down design is easy



# Instrument for nano-satellite

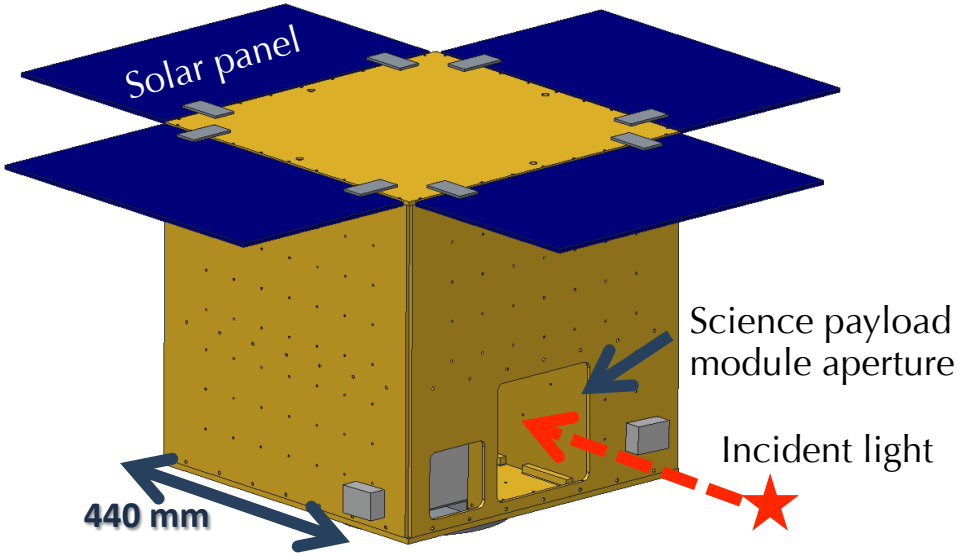
- Compact spectrometer at near-visible wavelengths < 1μm
  - Easy to design wide-field telescope with 20-mm aperture
  - Combined with micro spectrometer with the CMOS array sensor
- Requirements to the satellite
  - Detector temperature ~200K is easily obtained by TE-cooler or passive cooling
  - High pointing stability is required to have long exposure time

Micro spectrometer module
(Hamamatsu Photonics, C12666MA)

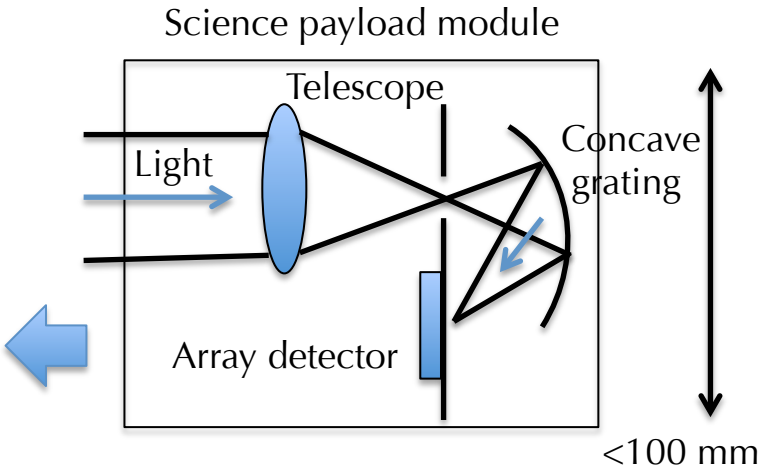
| Parameter | Value |
|---|---|
| Aperture size | 20 mm dia. |
| Field-of-view (FOV) | 0.1 deg x 10 deg (long slit) |
| Pixel FOV (128x128pixels) | 0.1 deg x 0.1 deg |
| Wavelength | 0.4-1 μm |
| Spectral resolution | 0.05 μm |
| Weight | < 1 kg |
| Electrical power | 1 W |
| Data size | ~ 10 kB/frame |
| Ambient temperature | 300 K (~200 K for detector) |
| Pointing stability | < 0.01 deg/min |

# An example of nano-satellite

- An example of nano-satellite as science platform designed by nano-sat team at Tokyo Metropolitan University
- Science payload: ~0.01 $m^3$, ~10 kg, >15W, ~20kB/day
- Sufficiently large resource for installing a compact near-infrared spectrometer, many rooms to design larger instr.




ORBIS mission lead by Dr. Sahara's group




Many options for spectroscopic system
- Prism, LVF, Interferometer

# Summary

- Investigation of the cosmic infrared background and the zodiacal light are important scientific objectives of today's astronomy.

- Spectroscopic measurement of the background radiation in the near-visible range demands only a non-cooled, compact spectrometer in the space.

- Our conclusion is: Top-science results can be achieved by using a nano-satellite system.