SPICA

Space Infrared Telescope for Cosmology and Astrophysics

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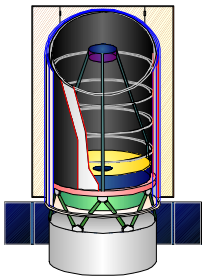
Birth & Evolution of Galaxies

Early Universe → Current Universe

- Star-formation History
  - MIR-FIR: less extinction, total energy (Deep Imag.)
  - Redshift: PAH features (Low resolution spect.)
- Birth & Evolution of AGNs
  - MIR Diagnostic Lines (Spect.)

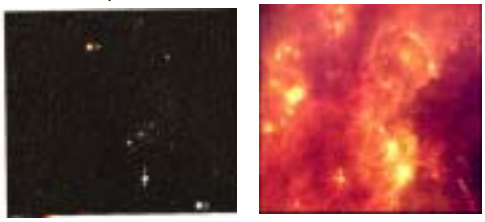
Outline of **SPICA**

- Telescope: 3.5m, 4.5 K
- Core λ: 5-200 μm
- Orbit: Sun-Earth L2 Halo
- Warm Launch, Cooling on Orbit
- Launch: ~2010



Birth & Evolution of Stars

Orion: Optical → Infrared



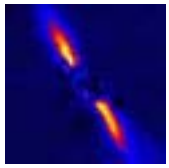
- Star-formation: Holy Grail of Infrared Astronomy
- Chemical Evolution of ISM (spect.)

Scientific Motivation

- History of our Univserse
  - Birth & Evolution of Galaxies
  - Birth & Evolution of Stars
  - Birth & Evolution of Planetary Systems

Formation of Planetary Systems

Proto-Planetary Disks



Exoplanets found !

- Systematic Study of Proto-Planetary Disks
  - High-Resolution Obs. on the basis of ISO, SIRTF, ASTRO-F
- Direct Detection of Jovian Planets
  - High-Resolution, High-Contrast Observations

Wanted !
A Large, Cooled Telescope

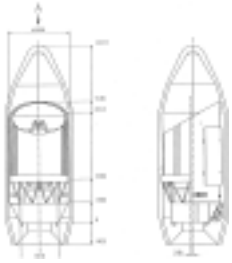
- Importance of Mid- and Far-Infrared
  - Beautiful results of ISO
- SIRTF and ASTRO-F
  - But they have D<1m
- HSO, JWST
  - But they are warm

↓

- We want a large, cooled telescope

Telescope Size

- The larger, the better, but….
- Feasible Size: D = 3.5 m
  - Much larger than those of previous missions (D < 1m)
  - Monolithic (not deployable) mirror → high feasibility

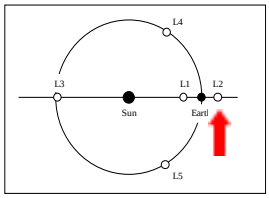


Design

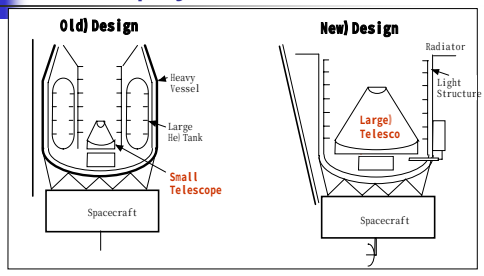
- Warm Launch
  - Cooling on orbit
- No Cryogen
  - Radiative Cooling & Mechanical Coolers

Warm Launch, Cooling on Orbit

- Effective Radiative Cooling
  - S-E L2 Halo Orbit
  - Easy Thermal Shielding
- Mechanical Cryocoolers
  - Essential for 4.5K

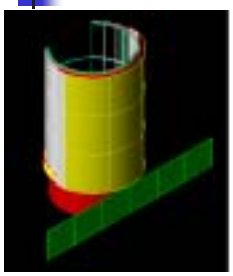


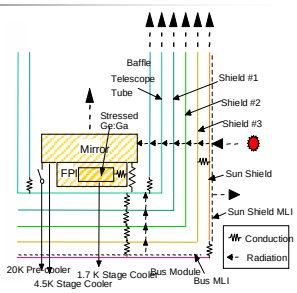
Revolution of Design Philosophy



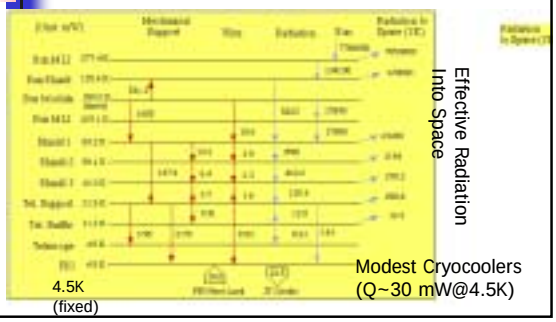
No Cryogen → Large Telescope

Thermal Model



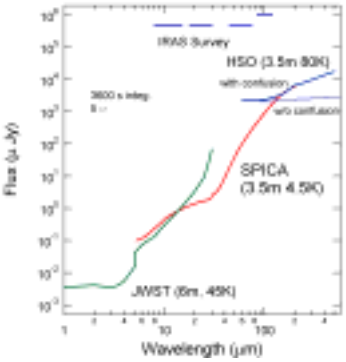


Heat Flow



SPICA Sensitivity

- Optimized for Mid- & Far-Infrared
  - Most Sensitive among proposed missions @ 15-130 μm
- Complimentary to HSO & JWST



SPICA Mission

- Telescope: 3.5m
- Launching Vehicle: H-IIA-202
- Orbit: Sun-Earth L2 Halo
- Warm Launch → Light Weight (2.6t)
- Radiation Cooling + Mechanical Cooler
  T_{TEL} = 4.5K, T_{FPI} < 4.5K (possibly < 2K)
- Launch: 2010

Technology Development Programs

- Mechanical Cryocoolers
- Light-weight Telescope

Focal Plane Instruments

- First Priority
  - Mid-Infrared Camera & Spectrometer
    - with Coronagraphic Capability
  - Far-Infrared Camera & Spectrometer
    - High Resolution
    - 3.5" @ 50 μm (c.f. 30" for ASTRO-F)
- Second Priority
  - NIR Camera & Spectrometer
  - Sub-mm Camera & Spectrometer

Cryocoolers

- Stirling Cooler (Precooling)
  - 200 mW @ 20 K
  - similar to those onboard ASTRO-F (2004)
- JT Cooler (1)
  - To cool Telescope and MIR instrument
  - 30 mW @ 4.5 K
  - similar to those onboard SMILES
- JT Cooler (2)
  - To cool FIR instrument
  - 10 mW @ 1.7 K
  - Under development

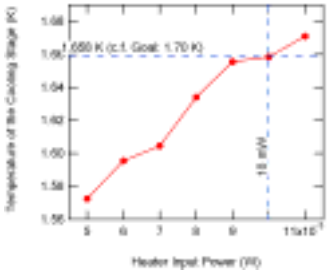
Stirling Cooler

ASTRO-F

- Goal: 200 mW @ 20 K → Ok !
- Working for more than 3 years !
- To be flight-proven in 2004

JT Cooler (2)

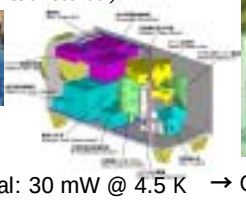
- It is Working !
- Results: 10mW @1.66 K
  - C.f. Goal: 10mW @ 1.7K



JT Cooler (1)

Developed for **SMILES**

(Superconducting Submillimeter-wave Limb-emission Sounder)



- Goal: 30 mW @ 4.5 K → OK !
- Working for more than 8,000 hours !
- To be flight-proven in 2005

Spec. of Telescope System

- 3.5m Clear Aperture
- Diffraction Limit at 5μm
  - Very Smooth Surface for Coronagraph
- Operation Temp. 4.5 K
- Light Weight < 700 kg
  - Area Density of Primary < 25 kg/m^2

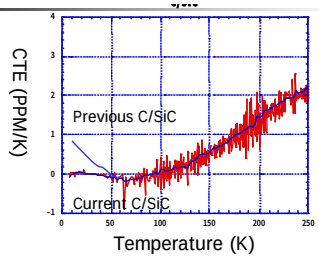
JT Cooler (2)

- Goal: 10 mW @ 1.7 K
- ^{3}He for Low Temp.
- Under Development

ASTRO-F Telescope

- 67 cm R.C.
- Oper. Temp. 5.8 K
- Diff. Limit @5μm
- SiC
  - Porous Core
  - CVD Coat
  - Area Density 28 kg/m^2
  - But D<1m

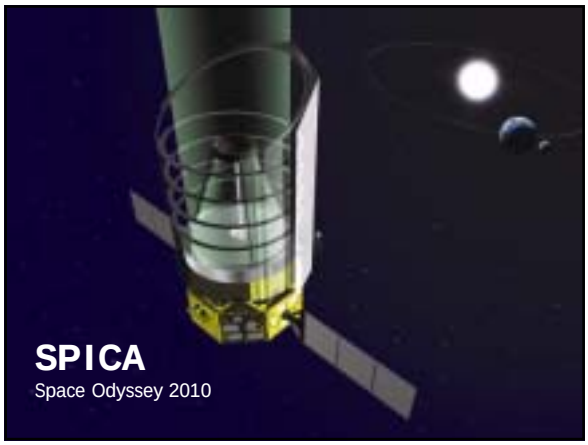
New Material C/SiC



- Advantage: Large Monolithic Mirror
- Disadvantage: Large CTE at low T? → Solved

Summary

- SPICA: 3.5 m telescope cooled to 4.5 K
  - Warm Launch, No Cryogen, Cooling on Orbit
- Optimized for Mid- and Far-Infrared Astronomy
- Ideal Successor of ISO, SIRTF, and ASTRO-F
  - A BIG Jump
- Complimentary to HSO and JWST
- High Feasibility
  - On the basis of technologies available now (or to be available soon)



日本の宇宙科学の将来構想

中川貴雄（宇宙科学研究所）

天体観測

- 恒星の世界へ
- 銀河の世界へ
- 宇宙の果てへ

1. Space Astronomy at ISAS

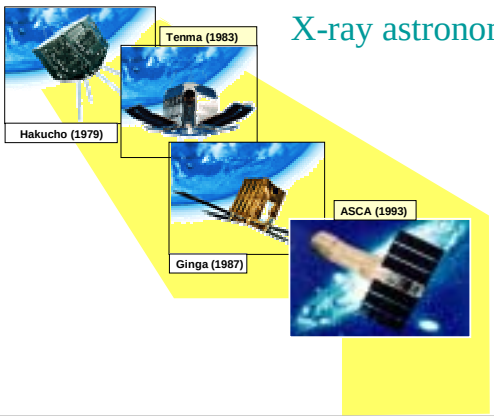
Scientific Objectives

1. Early Universe
   Formation of large scale structure and galaxies
2. Formation of stars and planets
   Origin of life
3. Physics in extreme condition
   Fundamental physics

X-ray	(ASCA) ⇨	ASTRO-EII ⇨	NeXT, XEUS
Radio	HALCA	⇨	VSOP-2
Infrared		ASTRO-F ⇨	SPICA
Solar Science		SOLAR-B	

ISAS SATELLITES AND SPACECRAFTS

X-ray astronomy



ASTRO-EII

- Recovery Mission of Astro-E
- Highest Spectral Capability in 3 - 10 keV
- Wide-band Spectroscopy over 0.5 - 600 keV

High Resolution Spectrometer
dE ≤ 10 eV
at 60 mK

- Mission – Start : April, 2001
- Launch : Scheduled in Jan.– Feb., 2005

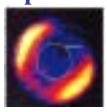
Radio Astronomy

HALCA satellite
Deployment of 8m antenna
Launched by M-V-1 in 1997

Angular Resolution
‖
λ／Diameter
6cm／30,000 km
‖
2／10,000 arc sec

Very Long Baseline
Interferometer in space

Future mission:
New X-ray Telescope Mission (NeXT)

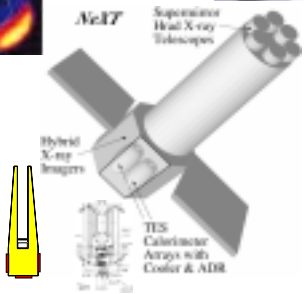


Scientific objectives

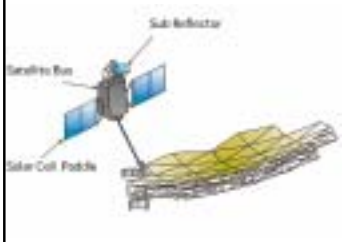
- ○Acceleration mechanism in Universe
- ○Structure and kinematics in Universe
- ○Evolution of Universe

Launch target: 2009

Launcher: M—V



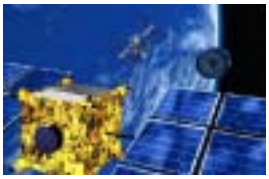
Future mission:
VSOP-2 Mission



- Space VLBI mission
  Successor of HALCA
- Compared with HALCA
  10 times higher sensitivity
  9 times better angular resolution
  (at 5 GHz)
- Specification of VSOP-2
  Telescope aperture *12m*
  Observation wavelengths
  38mm, 13mm, 7mm
  Orbit : perigee : 1,000km
  apogee : 30,000km
- Launch target
  On 2008 with M-V rocket

Future mission:
XEUS: X-ray observation of early Universe

International collaboration with ESA



Infrared Astronomy

IRTS (Infrared Telescope in Space)
15cm telescope cooled by liq.He
Launched on March 1995
1 month observation period

ISO: Infrared Space Observatory
ESA mission
ISAS contributed receiving station

ASTRO-F

First dedicated infrared mission of ISAS

Advanced Infrared Survey
50 times higher sensitivity,
10 times better spatial resolution,
has longer wavelength band,
than IRAS

Advanced cryogenic technology
With 2-stage Stirling refrigerator

Science: Formation and evolution of galaxies, stars, and planets

Launch : February, 2004
Orbit : sun synchronous orbit, 750km altitude
Mission life: >1 year (liq. He holding time)
+ 2 years (dedicated to NIR Observations)

月・惑星探査

- 固体惑星の起源
  - 月(LUNAR-A, SELENE)
  - 小惑星 (MUSES-C)
- 惑星大気・環境
  - 火星 (のぞみ)
  - 金星

Future mission: SPICA

SPace Infrared telescope for Cosmology and Astrophysics

L2 halo orbit, launched with H2A rocket
Telescope aperture ~3.5m
Temperature of the telescope ~ 4.5K
Warm launch, cooled in space
Effective radiation cooling
Mechanical cooler (JT)

Observatory for mid- and far IR astronomy
High spacial resolution,
High spectral resolution
in wavelength range 10μm ~200μm

Launch target ~2010

Complementary mission to NGST(1-10μm), FIRST(100μm-1mm)

Nozomi (Mars Orbiter)

Science targets

- Upper atmosphere
  - Solar wind interaction
  - Atmosphere escape
  - Magnetic field
- Dust
- Surface and subsurface

Launched : July, 1998
Mars Orbit Insertion : January, 2004

Solar Physics

Yohkoh satellite (1991-)

Hionotori satellite (1981-1991)

SOLAR-B(2005)

MUSES-C

Sample return mission
Target : 1998SF36

Engineering challenge
Electric propulsion
Navigation
Sample capture
Reentry

Launch : November, 2002 ∽January, 2003 M-V-5
Arrival : June, 2005
Return to earth : June, 2007

LUNAR-A

Penetrater mission

Lunar Seismology
Heat Flow
⇩
Internal structure of the Moon

Launch : August-September 2003
M-V-2
Lunar Orbit Insert : June-July 2004

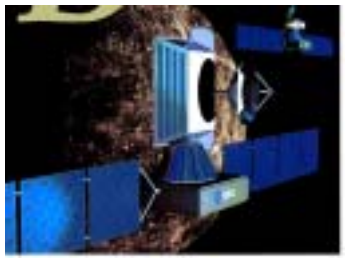
•Future mission: Bepi Colombo Mission (Mercury Exploration)

Comprehensive study of Mercury
global mapping
magnetism
atmosphere
magnetosphere

Under evaluation in SCSS

International collaboration
ESA :Senior partner
ISAS: Junior partner

Launch : 2009
Arrival : 2012



SELENE

Lunar remote-sensing mission

Lunar Orbiter Satellite + two Sub Satellites
Global Mapping of the lunar surface
14 science instruments for measurements;
elemental abundance, mineral composition, topography,
geological structure, gravity field, magnetic field,
plasma environment, and terrestrial atmosphere

ISAS-NASDA joint mission
Launch in 2005

Future Mission: GEOTAIL-II

・Multipoint measurements: Formation flight
・Particle acceleration in the Earth's magnetosphere
Magnetic reconnection
Shock

PLANET-C: Venus Climate Orbiter

Atmospheric dynamics
Remote sensing mission

ISAS approved, and is requiring budget

Launch : Feb.-Apr. 2007 (backup in 2008)
Arrival : September 8, 2009

3-D meteorological observation by multi-wavelength cameras

Near-IR *UV*

宇宙航空研究開発機構(仮称)

- 宇宙三機関 (NASDA, ISAS, NAL) の統合
- 2003年10月に、独立行政法人として発足
- チャンスか？危機か？