



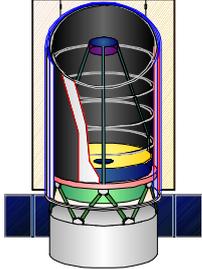
Birth & Evolution of Galaxies

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 : 5-200 μ m
- Orbit: Sun-Earth L2 Halo
- Warm Launch, Cooling on Orbit
- Launch: ~ 2010



Birth & Evolution of Stars

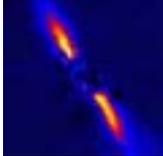
Orion: Optical	Infrared
	

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

Scientific Motivation

- History of our Universe
 - 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

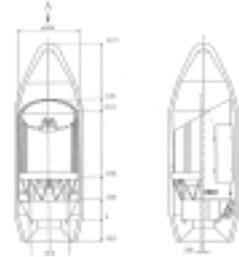
Wanted ! A Large, Cooled Telescope

- Importance of Mid- and Far-Infrared
 - Beautiful results of ISO
- SIRTf and ASTRO-F
 - But they have $D < 1\text{m}$
- HSO, JWST
 - But they are warm

- We want a large, cooled telescope

Telescope Size

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

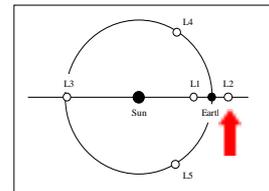


Design

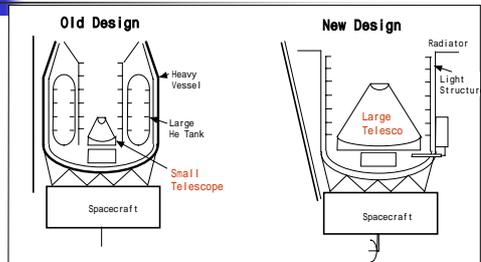
- Warm Launch
 - Cooling on orbit
- No Cryogen
 - Radiative Cooling & Mechanical Coolers

Warm Launch, Cooling on Orbit

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

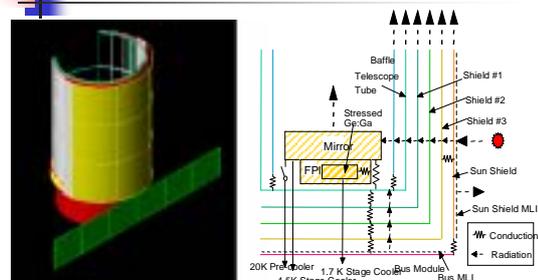


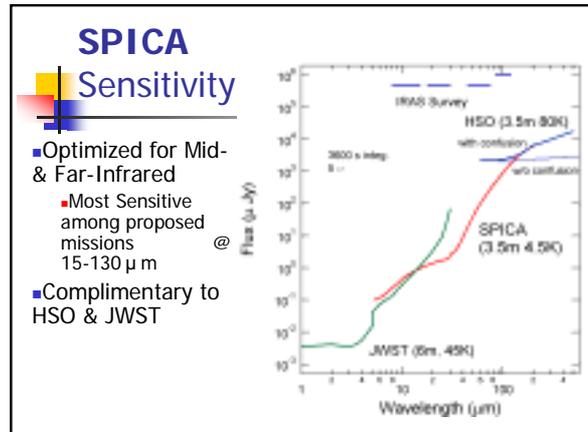
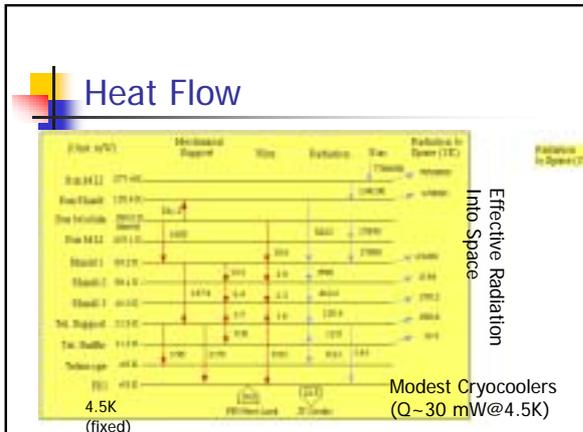
Revolution of Design Philosophy



No Cryogen Large Telescope

Thermal Model





- ## 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
 - $T_{\text{TEL}} = 4.5\text{K}$, $T_{\text{FPI}} < 4.5\text{K}$ (possibly $< 2\text{K}$)
 - 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



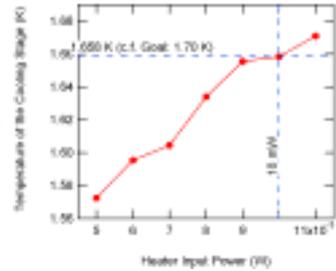
ASTRO-F



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

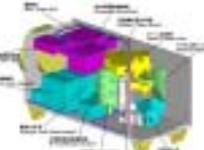
JT Cooler (2)

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



JT Cooler (1)

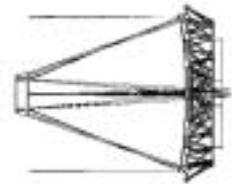
Developed for **SMILES**
(*Superconducting Submillimeter-wave Limb-emission Sounder*)



- 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 5 μ m
 - Very Smooth Surface for Coronagraph
- Operation Temp. 4.5 K
- Light Weight < 700 kg
 - Area Density of Primary < 25 kg/m²



JT Cooler (2)

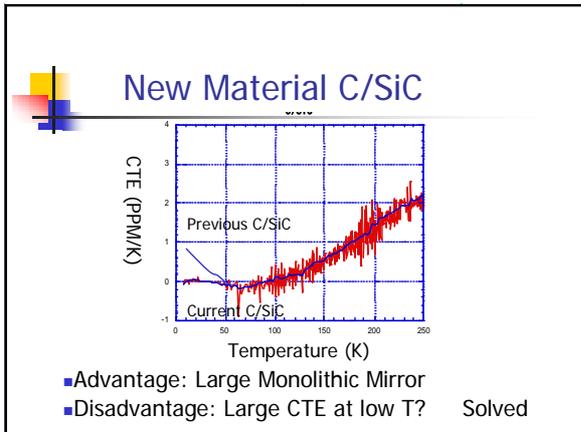
- Goal: 10 mW @ 1.7 K
- ³He for Low Temp.
- Under Development



ASTRO-F Telescope

- 67 cm R.C.
- Oper. Temp. 5.8 K
- Diff. Limit @ 5 μ m
- SiC
 - Porous Core
 - CVD Coat
 - Area Density 28 kg/m²
 - But D < 1m





- ## 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)

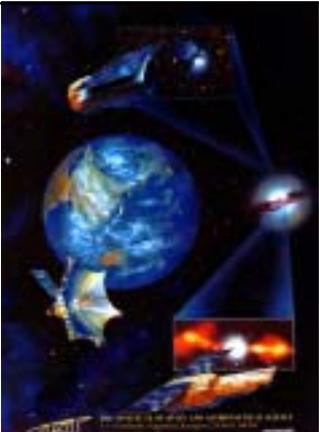


日本の宇宙科学の将来構想

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



日本の宇宙科学の将来構想

New Horizon of Space Science in Japan

温故知新



1. Space Astronomy at ISAS

Scientific Objectives

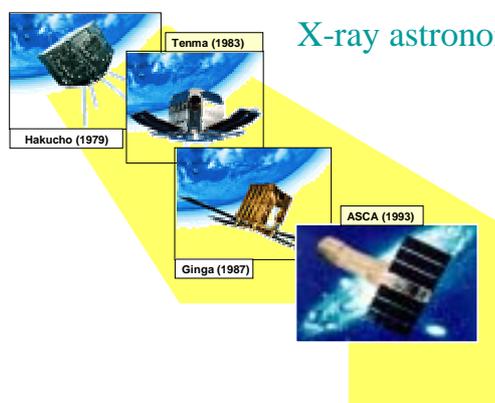
1. Early Universe
Formation of large scale structure and galaxies
2. Formation of stars and planets
Origin of life
3. Physics in extreme condition
Fundamental physics

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



Hakucho (1979)

Tenma (1983)

Ginga (1987)

ASCA (1993)

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
HE: 2 - 10 keV
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
||
 $\lambda / \text{Diameter}$
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:

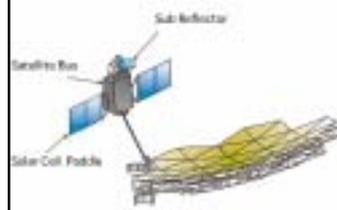
VSOP-2 Mission

• 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*

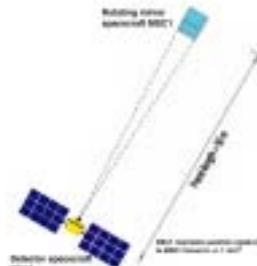
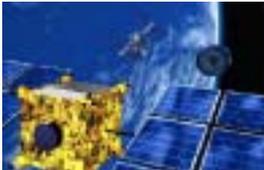
• Launch target
On 2008 with M-V rocket



Future mission:

XEUS: X-ray observation of early Universe

International collaboration with ESA



Infrared Astronomy



IRIS (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 10 μ m ~200 μ m

Launch target ~2010

Complementary mission to NGST(1-10 μ m), FIRST(100 μ m-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



Hionotori satellite (1981-1991)



Yohkoh satellite (1991-)

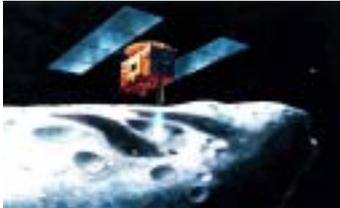


SOLAR-B(2005)

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

Penetrator 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



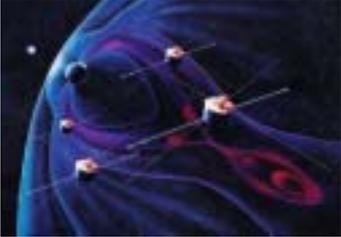
Lunar remote-sensing mission

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？