ISS/JEM

M. Tamura
T. Matsuo
(NAOJ)

ISS dimension ~ football stadium
ISS mass ~ Jumbo jet
ISS space = 1.5 x Jumbo jet
ISS orbit ~ 400 km above ground
90 min per orbit
Japanese Experiment Module (JEM): "KIBO (Hope)"

- Japan’s unique exposed platform on the ISS (power, coolant and data lines are provided)
- Observations fit to the orbit (~400km, 90min/orbit) and characteristics of ISS
- Development of technologies in the exposed space
Early Phase JEM-EF Missions : Observatory Sciences

• **MAXI (Monitor of All-sky X-ray Image)**
  - P.I. : Dr. M. Matsuoka (RIKEN)
  - MAXI monitors X-ray objects in the whole sky with high sensitivity.

• **SMILES (Superconducting Submillimeter-Wave Limb Emission Sounder)**
  - P. I. : Dr. H. Mashiko (CRL)
  - SMILES observes and monitors very weak sub-millimeter wave emission lines
    - of trace gas molecules in the stratosphere for the first time.

• **SEDA-AP (Space Environment Data Acquisition equipment - Attached Payload)**
  - Not introduced here.
  - see http://kibo.jaxa.jp/en/experiment/ef/seda-ap/
Overview of MAXI

- MAXI (Monitor of All-sky X-ray Image)
  - MAXI monitors X-ray objects in the whole sky with high sensitivity.
  - The first light image captured in August 2009
  - Capture so-called "all-sky X-ray moving image" once per orbit

First light: August 15, 2009
Overview of MAXI

- Dimension: 100 * 80 * 180 (cm^3), Total weight: 490kg
- MAXI employs slit cameras. The slit is orthogonally oriented to a one-dimensional position-sensitive X-ray detector.
X-ray sources detectability with MAXI

- 10 times more sensitive compared to that of the existing X-ray all sky type observatories.
2nd-phase observational sciences from JEM-EF

- 1\textsuperscript{st} phase: 2009-2011, 16 science themes (30 experiments in total)
- 2\textsuperscript{nd} phase: 2012-2015
  - a total of 11 candidate missions for conceptual study.
  - four candidates for port-sharing utilization missions were selected to move to the development phase.
    - IMAP (Ionosphere, Mesosphere, upper Atmosphere, and Plasmasphere mapping)
    - GLIMS (Global Lightning and Sprite Measurement Mission)
    - SIMPLE (Space Inflatable Membranes Pioneering Long-term Experiments)
    - REXJ (Robot Experiment on JEM)
- cf. 2\textsuperscript{nd} phase experiments for PM (Pressurized Module)
  - 14 among 18 space science programs are X ray sensor developments.
Summary of JEM-EF

- Number of ports: 10
- Standard envelope: 1.85m * 1.0m * 0.8m
- Mass: less than 500kg
- Services by KIBO
  - Electric power: max 10kW
  - communication
    - slow: bass line
    - medium: Ethernet
    - fast: optical fiber
- Coolant: liquid only, controlled temperature 20 +/- 4°C
JEM-EUSO
(Extreme Universe Space Observatory onboard Japanese Experiment Module)

- Not suitable for the standard exposed facility but the mounting support enables it to be installed...
- candidate as a 2nd phase observatory
- to be launched in 2013 by the Japanese heavy lift rocket - the H2B, and then conveyed to ISS by HTV (H-II transfer Vehicle)...
- a very wide-field, large-lens telescope (~60 degrees, 2.5 m diameter)
- Observe extreme energy particles with energy above $10^{20}$ eV and estimate arrival direction (air-shower observations from space, covering 500km area in once)
JEM-based exoplanet telescope?

- JEM-EUSO can be a good baseline for possible future exoplanet telescope using JEM

- The telescope parameters for JEM-EUSO
  - telescope aperture: 2.5m
  - 330-400 nm
  - operation: 3 years
  - total weight: ~1.2 ton
  - dissipation power: 800W
JEM-based exoplanet telescope?

- JEM exoplanet telescope?
  - possible to propose it for 3rd call??
- Above 2m diameter, off-axis
- Vis-NIR
- several coronagraphs sharing focal plane
- tip/tilt and AO system (disturbance conditions unknown)
- Field of view unknown
- Also suitable for transit all-sky survey or gravitational lensing
  - note MAXI can scan all-sky in every 90 min
- Concern about the pointing (this is not a problem for MAXI and UESO)
Far-Infrared Interferometric Telescope Experiment (FITE)

- PI H. Shibai (Osaka U.)
- Collaboration with Nagoya U., Tokyo U., JAXA, U. Sao Paulo, and INPE (20 members)
- Started from 2003
- Rehearsal already done in 2008
- First flight in Brazil in Autumn 2010
FITE Optical Design

Interferometer Optics

- Fizeau-type interferometer.
- First plane mirrors, secondary mirrors, off-axis parabola mirrors, sensor optics
- 40cm in diameter, baseline: 8m
Telescope Side

- Hanging Train
- Wide-Field Camera
- Telescope Structure (made of CFRP)
- Elevation Driver
- Primary Mirrors
- Cryostat
- Interferometer
- Control Gondola
Control Gondola

- Hanging Train
- Telescope Structure
- Control Electronics (6 CPUs)
- Li-Ion Battery
- Crash Pad (6 Positions)
- Telemetry/Command Antennas
- Tri-Axes Ring-laser Gyro
- Reaction Wheels (3 Sets)
Performance of Gyro (Ring laser gyro)

Resolution < 1arcsecond
Negligible Drift Error

Raw Signal 7”rms

Karman Filter + 10Hz LPF

Filtered Data 0.14”rms
FITE Summary

- **Structure**
  - Dimension: 8.5m x 4m x 2.5m (H)
  - Dry Weight: 1620 kg (without Ballast)
  - Structure: CFRP Pipes + Aluminum Pipes

- **Telescope/Interferometer**
  - Type: Two-Beam Fizeau-Type Interferometer
  - Mirrors: Four Plane Mirrors (SiC)
  - Two Off-Axis Parabolas (Zerodur)
  - Aperture: 40 cm (dia)

- **Sensors**
  - Far-Infrared: 15 pixel array (newly developed)
  - Beam Monitors: MIR 320x240 array + 3 CCDs
  - Cryostat: Super-fluid He (30 ltrs)

- **Control System**
  - Onboard System: 6 CPUs + Functions
  - Moving Part: 25 actuators
  - Battery: 300 AH @ 24 volts (Li-lon, rechargeable)
  - Data Rate: 192 kbps
  - Ground System: 8 QL Monitors + Video Camera Monitor
Backup slide
JEM-EUSO telescope

Infrared Cameras
Lidar
Atmospheric monitoring
Optical system
Iris
Front lens
Precision fresnel lens
Rear lens
Focal surface detector
Electronics
Tilt system
Grapple fixture system
Lid
Connects to the JEM/EF EFU
HII-B
Attitude Control for FITE

- FITE project aims for a spatial resolution of 1” (4” for the first flight)
  → Attitude stabilizing accuracy required is 1” (4” for the first flight)

- Adopt Three-axis Stabilized Attitude Control System
  - Hang the gondola at its gravity center
  - Control its three-axis attitude
  - Second trial in the world for balloon-borne telescope
Alt-azimuth Pointing System
~ traditional control system for balloon-borne telescope

- Control elevation angle + azimuthal angle
- The gondola is stabilized by gravity

![Diagram of Alt-azimuth Pointing System]

Pendulum motion of balloon-borne telescope (recorded at FIRBE observation, 2001)

Attitude stabilizing accuracy is few 10” – few ’ >> 1”
When the gondola is hung at its gravity center, ...

Attitude of the gondola does not change!

No couple of force
→ No pendulum motion

We can control its attitude with high accuracy
⇔ need to control its three-axis attitude
First Trial - December in 2008 in Brazil

Collaboration with Brazilian Institute for Space Science (INPE)