Athena &
Future plans of X-ray astronomy in Japan

Hiro Matsumoto (Nagoya U.)

Outline

• Japanese contributions to Athena
• Future Japanese projects
Athena (2028~)

Contribute to the success of Athena based on our expertise

ISAS/JAXA next 10-20 years

Strategic L-class mission (L class)

H-IIA, 3/10 years (ASTRO-H class)

Competitively-chosen medium-sized focused mission (M class)

Epsilon, 1/2 years, ~70MEuro (w/o rocket)

Mission of Opportunity (S class)

foreign agency-led missions, ISS, sounding rocket, etc. Total~10MEuro/year.
What is “ISAS pre-project”?

• ISAS officially supports Athena.
• Up to the mission adoption in ~2020.
Athena case

Researchers

ISAS steering committee

HEAPA Community

ISAS Working Group

Athena WG (Chair HM)

We are here!

ISAS Pre-Project

Future

ISAS pre-project

Mission adoption in 2020

ISAS/JAXA project

Launch in 2028
Contribution to X-IFU

X-IFU proto-consortium
K. Mitsuda (ISAS)
N. Yamasaki (ISAS)
H. M. (Nagoya U)

X-IFU scientist
Y. Fukazawa (Hiroshima U.)
SWG

Chairs (6)

SWG1 T. Ohashi
SWG 1.1 N. Ota
SWG 2.2 Y. Ueda
SWG 2.3 T. Tsuru (→Terashima)
SWG 3 H.M.
SWG 3.4 A. Bamba

+ 20 members

- Possibilities
  - WFI
  - TOO ground stations
  - Calibrations
  - etc.
ASTRO-H

Wide band (0.3—600keV)

Now under the final integration test! (~mid. Nov.)

To be launched in early 2016

Stay tuned!
What should we do?
ISAS/JAXA next 10-20 years

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**Basic timeline**

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<td>(Hayabusa2)</td>
<td>Mars mission</td>
<td>LiteBIRD/Solar Sail</td>
<td>(ASTRO-H)</td>
<td>L-class 1</td>
<td>L-class 2</td>
<td>(L3: SPICA?)</td>
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<td>ERG</td>
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Beyond AH and Athena

**Dim & Diffuse X-rays**

If Cosmology is correct

- Dark Matter: 26.8%
- Ordinary Matter: 4.9%
- Dark Energy: 68.3%
- Gas: ~46%
- Stars: ~7%
- Missing: ~47%

Where are missing baryons?
Warm Hot Intergalactic Medium (WHIM)

$T \sim 10^6 - 10^7 \text{K}$

Simulated by Yoshikawa et al. 2001

Characteristic X-rays from Oxygen

Galactic + BGD

WHIM ($z = 0.033$)
DIOS
--Diffuse Intergalactic Oxygen Surveyor--
PI: T. Ohashi
(Tokyo Metro U.)

Spacecraft mass = 700 kg

$S\Omega \sim 100 cm^2 \ deg^2$
$\Delta E < 5 eV$

TES + 4 stage XRT

$\Delta E < 5 eV$, $E = 0.1 - 1.5 \ keV$
$FOV \sim 50'$, $S\Omega \sim 100 cm^2 \ deg^2$
Expected 3D map at $z = 0.2$

Gas distribution at $z = 0.2$
(Takei et al. 2011)

OVII and OVIII simultaneous $5\sigma$
1 Ms per 1 deg field

0.5 – 1 Msec pointing per position. About 30 points mapped.
DIOS can pick up filaments and faint galaxy groups.
Overdensity $\rho/\langle\rho\rangle \sim 30$ is explored, revealing about 30% of baryons.

Beyond AH and Athena

Hard X-ray Imaging
Resolve the peak of CXB!

Key to clarify the evolution of SMBHs.

Resolve 80% of CXB in 10-40 keV

\[ S = 3 \times 10^{-15} \]

Based on a CXB model constructed below 10keV

\[ \Delta \theta = 10'', 15'', 20'' \]

\[ \Delta \theta < 15'' \]
NGHXT
Next Generation Hard X-ray Telescope

\[ E = 1 - 80 \text{ keV} \]
\[ \Delta \theta \sim 15'' \]

PI: K. Mori
(Miyazaki U.)

Detector
Active shield
+ Si SOI & CdTe

AH successor

Mirror
Glass or Si foils etc.
+ multi-layer

Possible collaboration with NASA/GSFC
Summary

- Athena
- ASTRO-H
- M3 in 2022
- DIOS, NGHXT