SMART-X, The Square Meter Arcsecond Resolution X-ray Telescope

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SMART–X

We have conceived an observatory with

• Chandra’s angular resolution: 0.5”

But

• Larger Area
  • Mass/Area = 1/50 Chandra
  • A factor of 30 more effective area

• Better Instruments

• Cost comparable to Chandra
Requires new technology: adjustable, nested, grazing incidence optics

- Deposited actuator layer: 1.5μ thick
- Mirror substrate: 0.4mm thick
- Outer electrode segment
- Inner actuator electrode
- X-ray reflective coating (e.g., Ir)

ΔR~0.5μ
“Science frontier area: The epoch of reionization”
Emergence of first galaxies and supermassive black holes
(Asto2010, top-level report)

- middle of reionization epoch
- first galaxies actively form stars
- early stages of SMBH’s merger trees

Credit: NASA/WMAP Science Team

Credit: reionization.org

das NASA Mirror Tech Days Rochester 07/31/2012
Reaching to z=10 with SMART-X

- Compared to Chandra, SMART-X has:
  - 50x soft-band throughput and 100x étendue (grasp),
  - same particle background
- In 80 ksec, reaches the depth of the longest Chandra exposure — 4 Msec Deep Field South.
- At z=10, SMART-X can see unobscured accretion
- 4 Msec reaches the sensitivity corresponding to:
  - $L_{\text{Edd}}$ for a SMBH progenitor with $M_{\text{BH}}=2,500 M_{\odot}$
  - Total $L_X$ from HMXB’s in a SFR=50 $M_{\odot}$/yr galaxy
    (excellent star formation indicator)
First galaxies and SMBHs

- At $z \sim 6$ for $L_x = 10^{41}$ erg/s; SMART-X $\sim 4$ cnts per 4 Ms.
- SMBH co-evolve with galaxies $z \sim 6$; detectable only in X-rays
- SMART-X can detect $10^3 - 4$ M$_{\text{solar}}$ black holes individually to $z = 15$ (280 Myrs)

Evolution of Structure
“What are the connections between dark and luminous matter?”
“How do black holes grow, radiate, and influence their surroundings?”
(Astro2010, panel on Galaxies across cosmic times)
Time-domain X-ray astronomy: Imaging

- Evolution of SNRs (Cas-A)
- Cooling of neutron stars
- Light echos from Sgr A*
- Long-term evolution of jets (M87)
- SN1987A
Strawman mission concept

- Benefits from *Chandra & Con-X/IXO/AXSIO* work
- 3 m diameter mirror, 10 m focal length
- fly to L2
- 30x *Chandra* area at $E < 2$ keV
- Possible instruments:
  - CAT gratings: $E/\Delta E > 4000$
  - Active pixel imager: 22’ x 22’ FOV, 1/3” pixels
  - Microcalorimeter: $\Delta E = 5$ eV, 5’ x 5’ FOV, 1” pixels
- Chandra heritage:
  - Pointing control and Aspect
  - Thermal control
  - Test and assembly
  - Operations and Software
  - Software architecture
Con-X/IXO Heritage:
- 0.4 mm thin glass
- Slumped to P/H shape
- Highly nested shells (292)

Glass mass 488 kg
~ 125 mandrels
8016 pieces
mass to area = 1/50 Chandra

NEED precise alignment
Less expensive than Chandra/IXO

- Big cost savings relative to IXO:
  - no extensible optical bench, simple focal plane
  - fewer instruments
- 4000 kg mass — including 20% reserve and 30% margin. ATLAS V 541 launch.
  - lighter mirrors, 1056 kg (70% of Chandra)
- Plan to achieve TRL 6 by 2019
- Mission cost ~ $2.5B (2012 $)
- Uses Chandra heritage
SMART-X capability
Summary

We have conceived an observatory which should be a strong candidate for the 2020 decadal review, and realization in the 2020’s

Much remains to be developed. We are simulating piezo figure correction to derive:
• Requirements for precision of the actuators
• Allowance for individual actuator failures

We have already proven concepts of piezoelectric adjustable optics for:
• Correction based on ground measurement only
• Correction of low order shape distortions