BEYOND THE X-RAY MISSION CONCEPTS STUDY

Rob Petre (NASA / GSFC)

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X-ray Concepts Study and Initial Response

- The X-ray Mission Concepts Study report was submitted to NASA HQ on July 20 and released on August 10
- Prime finding is that ~$1B class X-ray observatories that address most of the *IXO* science objectives are feasible (provided the key technology has been developed to TRL-6)
- NASA HQ has responded favorably to the study, in particular to the prime conclusion
- Two possible opportunities are under discussion by NASA for this decade:
  - The next "strategic" mission, if HQ retains "wedge" after JWST and decides against starting *WFIRST*
  - In addition to (or instead of) a "strategic" mission, HQ considering starting one or more "probe-class" missions by 2017
- We need to have a reasonably developed X-ray mission concept for either scenario, based on concept study findings
  - Low risk technical approach
  - All key components at or approaching TRL-6
  - Well validated cost estimate (internal plus ICE)

Near term plan

- A Technology Development Plan for the critical technology for the notional missions (mirrors, calorimeters, gratings, …) will be developed over the next few months
  - Refine the timescale and cost to bring needed technology to TRL-6
- A follow up study will be performed to maximize the science return for a $1B class mission concept
  - Community involvement needed to prioritize science objectives (starting from *IXO* and *NWNH*)
- Goal is to provide input needed by NASA for its mid-decade implementation plan (2015)
- Beyond near-term input, the community needs to develop a strategy for the next decade and beyond, based first on science priorities and second on attainable technology goals
- We need to pay attention to decisions being made in Europe and Japan, and work as an international community to achieve our goals (paying attention to lessons from IXO)

Technology Development Plan (TDP)

- The concepts study identified critical technologies for each notional mission
  - Assessed current TRL based on RFI responses
  - Compiled costs and timescale to TRL-6 provided by RFI responses (next slide)
- The Technology Development Plan will provide a detailed description of the technology needed and the path (milestones, timescales and cost) to TRL-6
- Such plans were developed several times over the course of the *Con-X/IXO* studies
  - These plans (plus RFI responses) will be used as the starting point for the TDP
- Updates of status, path to TRL-6 and cost will be solicited from technology development teams
- The TDP will offer costs, timescales for multiple funding scenarios
- Goal is to submit the TDP before the end of 2012

Technology cost estimate (from Study)

Table 6.7-1. Notional Mission Estimated Technology Development Costs

Technology	Current Performance	Goal	Applicable Missions	Cost per year (M$)	# years	Total cost (M$)	Ref
Calorimeters	16 pixels, TRL4	1840 pixels, TRL6	*AXSIO, N-CAL*	3.3	6	20	Kilbourne
Slumped glass optics	8.5", TRL4	10", TRL6	*AXSIO, N-CAL, N-XGS*	3	3	9	Zhang, CST
Wide field optics	17", TRL4	7", TRL6	*N-WFI*	4	4	16	CST
CAT gratings	TRL3	TRL6	*AXSIO, N-XGS*	2.7	3	8	CST/IXO Tech. Dev. Plan
OPG gratings	TRL3	TRL6	*AXSIO, N-XGS*	1	3	3	McEntaffer
X-ray CCDs for *N-WFI*	1k × 1k, TRL9	2k × 2k	*N-WFI*	1	2	2	CST
X-ray CCDs for *N-XGS*	0.3 Hz frame rate	15 Hz frame rate	*N-WFI, AXSIO*	1.5	2	3	CST
Total				15.5		57	

- Estimates are from RFI responses:
  - Assume single development, not parallel
  - Are highly optimistic
- Investment areas can be selected to match desired mission's needs
- Realistic estimate falls between total here and $200M in *NWNH*

Mission study

- Start with most capable notional mission (*AXSIO* or *N-CAL* + grating)
- Refine flow down of science objectives to key parameters
- Adjust instrumentation definition as necessary
- Identify descopes through instrument capabilities trades, e.g.,
    - Smaller mirror (diameter, focal length)
    - Simpler calorimeter (single array, stored cryogen cooler)
- Carry refined design through design lab(s) and followup
- Identify means of potential cost savings; e.g., foreign partnerships
- Parametric costing and Independent Cost Estimate(s)
- Study must be complete by end of FY14 for input to mid-decadal

Table 5.1-4: Primary IXO/Decadal Science Objectives Addressed by Notional Configurations					
Science Question	IXO Approach	AXSIO ($1.5B)	Notional Cal ($1.2B)	Notional Grating ($0.8B)	Notional WFI ($1.0B)
What happens close to a black hole where strong gravity dominates?	Measure the strong gravity metric via time resolved high resolution spectroscopy of stellar mass and ~30 SMBH at Fe-K and possibly Fe-L	Measure the strong gravity metric via time resolved high resolution spectroscopy of stellar mass and ~20 SMBH at Fe-K and possibly Fe-L [1]	Measure the strong GR metric via time resolved high resolution spectroscopy of stellar mass and ~ 10 SMBH at Fe-K [2]	Measure the strong GR metric via time resolved high resolution spectroscopy of stellar mass and ~ a few SMBH at Fe-L (speculative) [2-3]	Measure the strong GR metric via time resolved low resolution spectroscopy of stellar mass and ~ 10 SMBH at Fe-K [2]
When and how did SMBH grow?	Mergers and accretion impart differing amounts of spin to SMBH. Determine how SMBH grow via measuring the distribution of spin using >300 SMBH within z < 0.2 using orbit-averaged relativistic Fe-K lines	Measure how SMBH grow via determining the distribution of spin using ~60 nearby SMBH using orbit-averaged relativistic Fe-K lines [2]	Measure how SMBH grow via determining the distribution of spin using ~40 nearby SMBH using orbit-averaged relativistic Fe-K lines [2]	Measure how SMBH grow via constraining the distribution of spin using a few nearby SMBH using orbit-averaged relativistic Fe-L lines (speculative) [3]	Measure when SMBH grow via determining the census of AGN out to z~6; measure AGN power spectrum to infer the halo occupation density over a range in z [1-2]
How does large scale structure evolve?	(i.) Find the missing baryons and determining their dynamical properties via absorption line spectroscopy of the WHIM over >30 lines of sight using AGN as illumination sources.	Find the missing baryons and determining their dynamical properties via grating absorption line spectroscopy of the WHIM over >30 lines of sight using AGN as illumination sources. [1]	Find the missing baryons via absorption line spectroscopy of the WHIM over <30 lines of sight using AGN as illumination sources (speculative). [2-3]	Find the missing baryons and determining their dynamical properties via absorption line spectroscopy of the WHIM over >30 lines of sight using AGN as illumination sources. [1]	
	(ii.) Measure the evolution of the cluster mass function using ~500 clusters of galaxies at redshift 1-2	Measure the evolution of the cluster mass function using ~ 150 clusters of galaxies at redshift 1-2 [2]	Measure the evolution of the cluster mass function using 50-100 clusters of galaxies at redshift 1-2 [2]		Measure cluster mass function by detecting 5000 clusters, ~ 1000 at z>1 in surveys (TBD); detection of protoclusters at earliest stages of formation (z~2) [1]
Connection between SMBH and large scale structure ?	Determine the energetics of SMBH outflows via measurements of the velocity structure of hot plasma in ~300 galaxies and clusters; measure the metallicity distribution in galaxies and their halos	Determine the energetics of SMBH outflows via measurements of the velocity structure of hot plasma in ~70 galaxies and clusters; measure the metallicity distribution in galaxies and their halos [2]	Determine the energetics of SMBH outflows via measurements of the velocity structure of hot plasma in ~50 galaxies and clusters; measure the metallicity distribution in galaxies and their halos [2]	Determine the energetics of SMBH outflows in ~ 30 AGN winds via ionization time variability; probe hot galaxy halos via background AGN absorption lines [2]	Measure metallicity distribution in ~ 100 clusters at z> 1; measuring morphology of ~ 100 clusters at z > 1 [2]
How does matter behave at very high density?	Measure the equation of state (mass and radius) of neutron stars via spectroscopy of ~ 30 bright neutron star X-ray binaries.	Measure the equation of state (mass and radius) of neutron stars via spectroscopy of ~ 20 bright neutron star X-ray binaries [1]	Measure the equation of state (mass and radius) of neutron stars via spectroscopy of ~ 20 bright neutron star X-ray binaries [1]	Measure the equation of state (mass and radius) of neutron stars via spectroscopy of rare transient slow-rotator neutron star X-ray binaries [2-3]	Measure the equation of state (mass and radius) of neutron stars via spectroscopy of a few bright neutron star X-ray binaries, using absorption lines in the burst rise and tails (speculative). [3]
	Measure the equation of state (mass and radius) of neutron stars via timing of ~ 30 bright neutron star X-ray binaries.	Measure the equation of state (mass and radius) of neutron stars via timing of ~ 20 bright neutron star X-ray binaries [1]	Measure the equation of state (mass and radius) of neutron stars via timing of ~ 20 bright neutron star X-ray binaries [1]		Measure the equation of state (mass and radius) of neutron stars via timing of a few bright neutron star X-ray binaries during burst rises and tails. [3]

Legend:
[1] Accomplishes IXO science goal fairly well
[2] Accomplishes IXO science goal moderately well
[3] Accomplishes IXO science goal marginally

Community involvement

- Community has already played a major role in the development of this plan through the study CST and the December 2011 workshop
- Continued community involvement is important
- For the TDP, technology teams will be asked to provide technology status and plan, and budget estimate
- TDP will be made available for comment by the SAG, PAG
- For the mission study, community involvement in some TBD way (SDT or equivalent)
- Regular discussions of status and issues through X-ray SAG
- AAS town halls – already have one scheduled for January 2013