Science Review: BEST Reviewed by CST and Support Team

Overview: The Black Hole Evolution and Space Time (BEST) Observatory is a ~ $600M mission to perform imaging spectroscopy in the 5-70 keV band and polarimetry in the 2-70 keV band in low earth orbit. BEST plans to take advantage of improvements in the mirror technology used for NuSTAR to provide imaging performance of 10" at 4.5 keV and larger collecting area than NuSTAR or GEMS. BEST plans to use CdZnTe detectors for the hard X-ray imager/spectrometers and a hybrid detector of a Time Projection Counter (similar to GEMS) for low energies and a new plastic scintillator detector developed for a balloon flight for the higher energies as the polarimeters. With the larger collecting area and better imaging performance, BEST promises significant improvements over NuSTAR and GEMS. The RFI response provides detailed information on how BEST can address IXO science objective #1 and some information on objectives #2 and #5. However, there is very little detail regarding Large Scale Structure and AGN/feedback science measurements (one paragraph covers those two science subtopics), so it is difficult to evaluate if BEST can do anything significant in those areas.

What happens close to a Black Hole?

Concept	Measurement
Strong gravity predicts effects on X-ray spectra	*In principle yes, but with 10x lower energy resolution than CCDs*

Concept	Measurement
Study behavior of matter/spacetime close to event horizons of BHs, polarization fraction and angle as function of E depends on BH spin	Time and energy resolved polarimetry observations of galactic black holes, AGNs and AGN jets

Polarization increases with energy (see Fig 1) and BEST will have multiple (~30) energy bins as compared to just a handful (2-4) that GEMS has to measure polarization as a function of energy. The energy-dependence of polarization is an indicator of spin. Polarimetry also tests models of the magnetized coronae and jets. The RFI did not contain an estimate or a simulation of the expected signal in the ~30 spectral bins to demonstrate that the data will be of sufficient quality to constrain accretion disk models.

When and how did super massive Black Holes grow?

Concept	Measurement
Measure evolution of SMBHs 0< z<6, calculate accretion budget of Universe by uncovering obscured SMBH	AGN hard X-ray survey down to F(6-10 keV)= 10^{-16} cgs

Even the deepest 0.5-10 keV X-ray surveys (the Chandra Deep Fields) are missing heavily obscured AGN so one has to move to the hard X-ray band to make progress. Note that the quoted sensitivity is in the 6-10 keV bandpass, which is within the bandpass typically used for the existing deep surveys. The imaging spectrometer uses CdZnTe detectors. It would be useful to include a figure with the instrument response, especially at energies above 10 keV.

It is convincing that a CdZnTe detector matched with a mirror that provides 10" angular resolution would do much better than NuSTAR in a hard X-ray survey, but there are few details about the hard X-ray survey in the RFI response.

How does large scale structure evolve?

Concept	Measurement
Map out cosmic web of structure by tracing AGN study co-evolution of AGN and their hosts	AGN survey, cross-correlate with galaxy survey

Concept	Measurement
Measure effects of cosmic structure formation	Make maps of non-thermal emission from large scale structure shocks

The section on the two science areas (large scale structure and AGN/feedback) is only a short paragraph. There is little detail on what BEST can achieve for this objective.

The RFI states that BEST will measure inverse Compton emission from non-thermal electrons accelerated at large scale structure formation shocks. There is no detail provided as to how this constrains the evolution of large scale structure.

What is the connection between supermassive black hole formation and evolution of large scale structure (i.e., cosmic feedback)?

Concept	*Measurement*
Resolve cluster bubbles and cavities and AGN jets where energy from AGN is deposited	*Measure high energy spectra of bubbles, searching for non-thermal componenet*

The RFI contains little detail on this objective. The spectral resolving power of the CdZnTe detectors limits what can be learned from the spectra.

How does matter behave at very high density?

Concept	Measurement
NS EOS can be determined by measuring M,R for a range of NS	Use X-ray spectra to measure surface thermal emission of NS, thus constraining M,R

Concept	Measurement
Use polarization information to refine determinations of emission location thus improving M/R measurements	Hard X-ray polarimetry measurement of NS and magnetars

BEST will measure spectra to get thermal emission properties to constrain mass and radius of a NS in outburst. There is no detail on what the spectrum is expected to be for a NS in outburst.

Polarization information can be used to tighten emission locale constraints, but the RFI response does not explain how. BEST's hard X-ray sensitivity will extend X-ray polarimetry measurements of NS to E>10 keV where magnetars have outbursts, possibly permitting the first measurements of the EOS for magnetars. This would be an important measurement.