ISS-Lobster
A Low-Cost, Wide-Field X-Ray Transient Mission on the ISS

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iLobster Objectives

X-Ray Time Domain Astronomy In ISS Era

- 30 x higher sensitivity compared to BAT, ASM, MAXI, for transient study of Black Holes, Neutron Stars, GRBs

- Multiwavelength analysis with LIGO, Fermi, JWST, ground telescopes
ISS-Lobster Mission Proposal

• ISS-Lobster proposed to 2012 NASA Mission of Opportunity
  • $60M
  • Power and communication provided by ISS

• Opportunity cancelled in April 2013 due to lack of funds in FY14 budget

• Received positive review of proposal
  • Strong science
  • Simple and robust implementation
  • Cost fidelity

• Will re-propose in Fall 2014
Lobster-Eye geometry provides *simultaneous* large FoV, high position resolution and high sensitivity → Time Domain Astronomy
iLobster and its Instruments

Wide Field Imager (WFI)
GSFC, U. Leicester, MIT
FoV: 0.3 sr = 900 deg²
Resolution = 1 arc min
Energy Range: 0.3 - 6 keV
Detectors: CCDs
Optics: Microchannel plates
Sens: $10^{-11}$ erg cm⁻² s⁻¹ (2000 sec)

Gamma-Ray Burst Monitor (GBM)
50 keV to 1 MeV
GSFC, MPE

Pointing Platform
1 arc min stability
2 $\pi$ FoR
Partner: Moog/CSA
ELC Locations

Oval shows the 8 good zenith-looking locations. Initially 2pi FoV.
ISS provides power, telemetry
Every New Technology Has Its Day

• Lobster optics proposed by Roger Angel in 1977

• All-Sky X-ray Monitor based on Lobster optics selected by ESA for flight on ISS in 2001 (U. Leicester)
  – Cancelled after Columbia accident

• Lobster-based satellite proposed by Gehrels in 2010
  – Category I but not selected

• Lobster optics now integrated into Beppi-Columbo mission (2015) for X-ray analysis of Mercury surface

• ISS-Lobster proposed for 2012 Mission of Opportunity
  – cancelled in 2013
Science Objective I
X-Ray Followup of Gravitational Wave Detection

- Several / yr (NS-BH) or (NS-NS)
- Increase range, confidence of LIGO detections
- Precise localization of source (redshift)
- Energetics of source
- Relative speed of graviton and photon \(10^{-18}\)
Science Objective 2
Highest Sensitivity X-Ray Transient Science

**Highest Sensitivity Time-Domain Survey of the Transient Soft X-ray Sky**

**With a 30-fold improvement in sensitivity beyond previous all-sky X-ray telescopes, ISS-Lobster will dramatically extend the discovery space for transient X-ray sources involving black holes and neutron stars. The near continuous ISS-to-ground communications link will allow transient alerts to be rapidly delivered to ground and space observatory networks.**

**Supernova Shock Breakouts** are the elusive short bright X-ray ashes signaling SNe explosions. ISS-Lobster will detect them at a rate of 1-2/yr.

**Binary neutron-star and neutron star -- black hole mergers** are thought to produce both short-lived strong gravity waves and electromagnetic signals. ISS-Lobster will detect these counterparts and provide insight into both their progenitor systems and the dynamics of strong gravity.

**Active Galactic Nuclei** will be densely monitored by ISS-Lobster, to detect modulated X-ray flux associated with the circumbinary disc inspiral of supermassive black hole binaries.

**Tidal Disruption Flares** signal the demise of a star when it wanders too close to a super massive black hole in the center of a galaxy. ISS-Lobster will detect ~14 such per year, elucidating stellar dynamics, and providing massive black hole demographics.

**Classical and Recurrent Novae** are the results of thermonuclear burning on the surface of a white. ISS-Lobster will detect X-rays from their runaway phases.
Science Objective 3
Gamma-Ray Bursts from early Universe

10% of ISS-Lobster's detected Gamma-ray Bursts will be high redshift (z>5). Assuming a 30% efficiency of redshift determination by ground-based telescopes, 10 high redshift GRB locations will be passed to JWST for early universe investigations, including chemical evolution and history of reionization.
X-Ray Followup of GW Detections by Pulsar Timing Array

• A PTA may observe stochastic GW background by ~ mid-decade
  • SMBH binaries with mass > $10^8 \, M_\odot$ and periods of 0.5 year or greater

• Discrete SMBH binaries could be seen above background if they are close
  • PTA can only localize to ~100 deg$^2$, but iLobster could find host galaxy

• All-sky iLobster monitor could observe and localize numerous SMBH sources if:
  • X-Ray emission from circumbinary disc modulated at ~ 10% level
  • Period of 1 year or less
  • $10^{-3}$ SMBH/Mpc$^3$ and 0.3 galaxy mergers /Gyr/galaxy

GW will disturb pulsar radio signal arrival times on Earth, observed by PTA
Observational Scenario

• Sky Survey mode (90%)
  • 2% FoV → 1100 sec per observation
  • 5 observations per orbit
  • Full sky coverage in 15 orbits

• Target of Opportunity (10%)
  • 5 min latency for ground pointing command
  • 2700 sec observation ("stare" mode)
Summary

• iLobster science is broad and fundamental
  – Gravitational wave follow-ups (stellar mass BH and SMBH)
  – Tidal disruptions of stars, SN shock breakout, NS bursts
  – High redshift Gamma-Ray Bursts

• Proposed to 2012 Mission of Opportunity
  – Positive review: affirmed science and cost of mission
  – Opportunity cancelled

• Will propose to 2014 Mission of Opportunity