HaloSat – A CubeSat to Study the Hot Galactic Halo

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Scientific Motivation

- Observations fail to locate about half of the baryons required in cosmology.
- Missing baryons may be in hot galactic halos.
- HaloSat will map O VII and O VIII line emission and constrain the mass and spatial distribution of hot gas around the Milky Way. HaloSat will address the question: Is there a massive, extended, hot halo around the Milky Way?

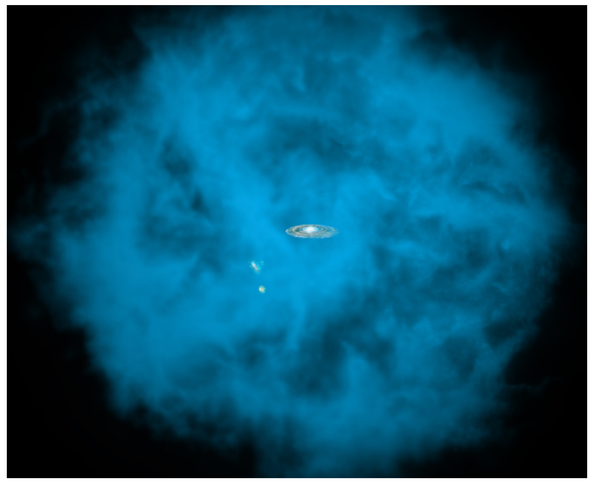
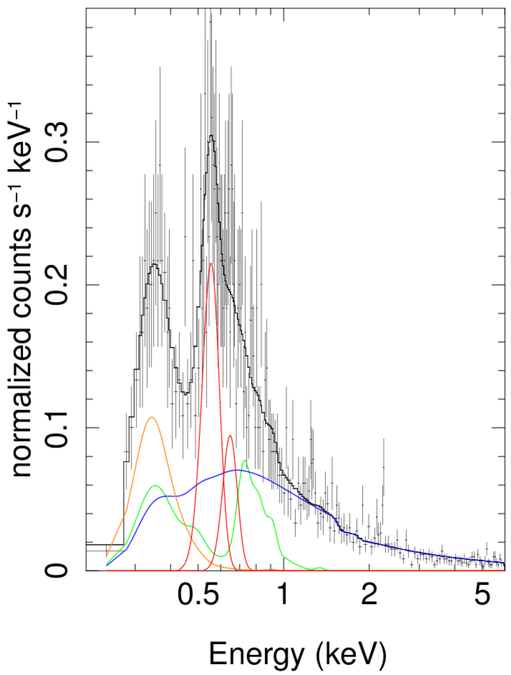


Image of the Milky Way and Magellanic galaxies embedded in a hot halo of gas from Gupta et al, (2012).

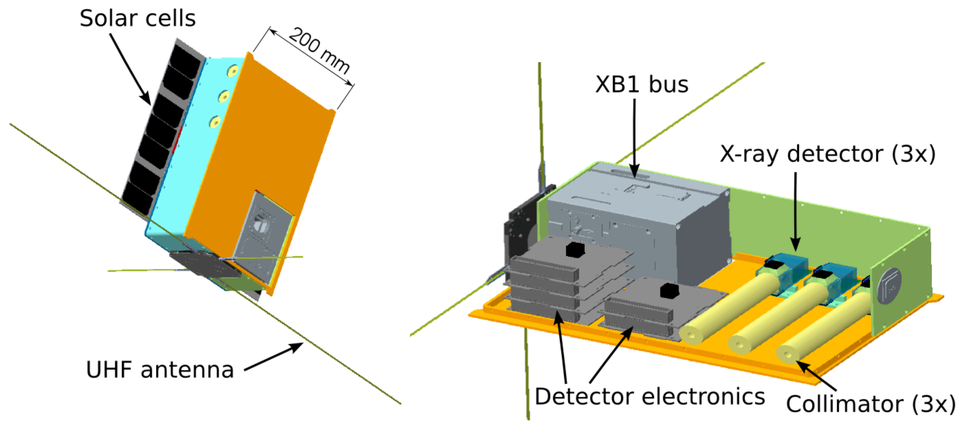
Evidence for an extended Galactic halo has been obtained from high-resolution absorption line spectra. However, absorption measurements depend on the fortuitous presence of a bright extragalactic continuum source and are possible only along a limited number of lines of sight. Emission lines can be measured in any direction. HaloSat will conduct a near all-sky survey of oxygen line emission with the goal of constraining the mass and spatial distribution of hot gas associated with the Milky Way. Constraints on the hot Galactic halo will help address the cosmological missing baryon problem (Wang & Yao 2007; Nicastro et al. 2012; Gupta et al. 2012; Henley & Shelton 2014).

Observational Goals

- Isolate the oxygen emission line complex in spectra, $\Delta E < 100$ eV.
- Measure the oxygen emission in 400 fields over 90% of the sky. Each field is roughly 10° × 10°.
- Obtain sufficient statistics for each field so the accuracy of the total oxygen line strength is limited by the solar wind charge exchange (SWCX) background to typically ±0.5 line units (LU)..
- Study the SWCX emission in order minimize its contribution to the uncertainty on the oxygen line emission measurements.

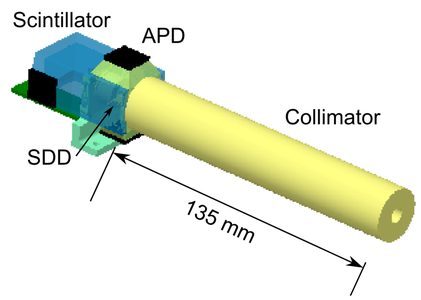


Simulated spectrum for a 5000 s observation with two active detectors of the soft X-ray background in the 0.2-6 keV band as measured by McCammon et al. (2002). The spectrum was modeled with the sum of two oxygen emission lines at 561 and 653 eV (red), an absorbed hot plasma with oxygen emission removed (green) for the distant (halo) emission, an unabsorbed cooler plasma with oxygen emission removed (orange) for local emission, and an absorbed power-law for extragalactic emission. The total oxygen line emission is measured to an accuracy of 9%.



Mission Concept

- HaloSat is a 6U CubeSat using commercial components to minimize cost and risk including the Blue Canyon Technologies XB1 bus and the L3 Cadet radio.
- The X-ray detectors are silicon drift detectors (SDDs) commercially available from Amptek. Three redundant detector assemblies include an SDD, X-ray collimator, anti-coincidence shield, and all electronics. The baseline mission requirements can be achieved with two operating detectors; the minimum mission with one detector.
- HaloSat is an operationally driven mission. Margins are not maintained on an orbit by orbit basis. Instead, spacecraft capabilities are traded for mission duration with technical margins translated to a required fraction of orbits allotted for charging, transmitting, pointing, and de-torquing.



Conclusions

HaloSat will:

- Help resolve the missing baryon problem via mapping the distribution of hot gas in the Milky Way revealed by oxygen line emission.
- Be executed by an experienced team at modest cost and with low risk by exploiting proven technologies.
- Train junior researchers for future roles in NASA missions.