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Future Japanese X-ray TES calorimeter satellite: DIOS (Diffuse Intergalactic Oxygen Surveyor)

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We present the latest update and progress on the future Japanese X-ray satellite mission DIOS (Diffuse Intergalactic Oxygen Surveyor)[1]. DIOS is proposed to the 4th mission in

Japan Aerospace Exploration Agency (JAXA) series on small projects, supposed to be launched around early 2020 by JAXA's new-type rocket called Epsilon. DIOS can inherit the legacy of ASTRO-H satellite[2], which carries semi-conductor calorimeters launched in 2015, and contribute to the next European X-ray mission ATHENA (~2028) in terms of delivering plenty of lessons regarding 400 pixel TES operation in space with cryogen-free cooling system. We have been sophisticating the entire design of the satellite to meet the requirement for the Epsilon payload for the next call expected in late 2015. The goal of the mission is to search for warm-hot intergalactic medium (WHIM) with high-resolution X-ray spectroscopy by detecting redshifted emission lines from OVII and OVIII ions. It will reveal the existence of "dark baryons" and its amount and spatial distribution on cosmological time scale.

Baryon census has been intensively studied with diffuse gas around galaxies and their clusters. However, majority of baryons (30-50%) in the local universe remain unexplored, therefore named as ''dark baryons''. Cosmological simulations and recent observations indicate that dark baryons exist along the large-scale filaments in the form of WHIM with temperatures between 10^5 and 10^7 K, meaning that X-rays are the ideal tool to probe WHIM through emission or absorption features. X-ray observation on WHIM will directly tell us how it is spatially distributed at different redshifts and how it evolved and created a large-scale structure in the universe. Although there were a few observations with grating spectrometers, the detection was quite difficult due to its low density. TES microcalorimeters combined with a very wide field of view (30--50 arcmin diameter) will enable us to map the WHIM for within three years, an expected lifetime of the small satellite. Furthermore, we pursue to expand the scientific possibility of DIOS to study cosmic plasma dynamics in a wide range of scales from Earth's magnetosphere to unvirialized regions of clusters of galaxies, by organizing the observational program of DIOS to achieve other astrophysical outcomes for a relatively short exposure.

According to JAXA's roadmap for space science and exploration released in 2013, the design of DIOS is extended to incorporate the ideas of larger X-ray telescope with a focal length of 1.2m, and fast repointing capability to observe afterglow of gamma-ray bursts. We also refined the payload design, such as weight, electrical power and thermal budget, communication and attitude control, and configuration in the fairing, resulting in a mission mass of 320kg (720kg in total) and a mission power of 380W (730W in total) which leave more than 10% margin. We have been developing 400 pixel TES using multi-layer wiring technique[3] and frequency domain multiplexing readout with digital base-band feedback method[4]. Detector design will be finalized by investigating technical readiness level and trade-off between frequency and time domain readout. if DIOS is successfully selected as the 4th Epsilon mission in 2015-2016, it will fly in early 2020, giving us a nice extension of the high-resolution spectroscopy starting with ASTRO-H, and a pathfinder for ATHENA. We would like to stress that DIOS is based on long-lasting international collaboration for dark-baryon missions from ESA's Cosmic Vision (EDGE and ORIGIN) to the US Decadal Survey (Xenia).

References:
[1] Ohashi et al. 2014, Proceedings of the SPIE Astronomical Instrumentation
[2] Takahashi et al. 2014, Proceedings of the SPIE Astronomical Instrumentation
[3] Ezoe et al. 2014, Applied Superconductivity Conference 2014, Charlot, USA
[4] Sakai et al. 2014, Journal of Low Temperature Physics