Breakthrough capability for the NASA Astrophysics Explorer Program: Reaching the darkest sky

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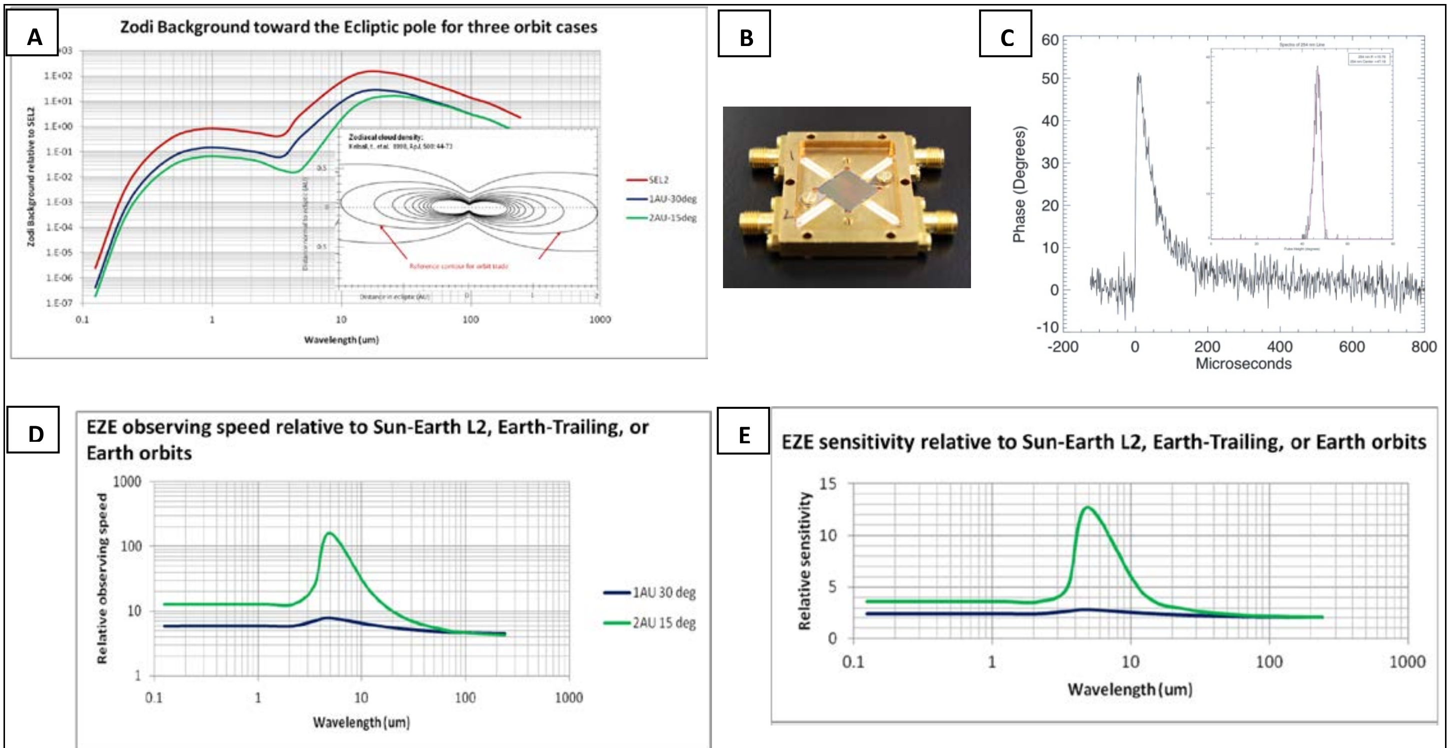
We describe an Extra-Zodiacal Explorer (EZE) mission architecture designed to substantially increase the science capability of the NASA Science Mission Directorate (SMD) Astrophysics Explorer Program for all AO proposers working within the near-UV to far-infrared spectrum. We have demonstrated that augmentation of Falcon 9 Explorer launch services with a 13 kW Solar Electric Propulsion (SEP) stage can deliver a 700 kg science observatory payload to extra-Zodiacal orbit[1]. This capability enables up to ~13X increased photometric sensitivity and ~160X increased observing speed relative to a Sun-Earth L2, Earth-trailing, or Earth orbit with no increase in telescope aperture. We demonstrate that enabling Astrophysics Explorers to reach extra-zodiacal orbit will allow this small payload program to rival the science performance of much larger long development time systems; thus, providing a means to realize major science objectives while increasing the SMD Astrophysics portfolio diversity and resiliency to external budget pressure.

When the dark sky advantage shown below is combined with photon counting detectors that effectively yield noiseless detection of light, an additional order of magnitude increase in observatory performance can be achieved if focused detector technology investments are made during this decade. A notable example is shown below. Microwave Kinetic Inductance Detectors (MKID) are applicable across the UVOIR spectrum and, in contrast to semiconductor-based detector technologies such as CCD and HgCdTe, superconducting MKIDs count single photons with no false counts while determining the energy (to a few percent) and arrival time (to ~ 10^{-6} s) of the incoming photon[2]. The first optical/nIR MKID camera, the ARray Camera for Optical to Near-IR Spectrophotometry (ARCONS), was commissioned during 2011 at the Palomar 200 inch telescope, and includes a 2024 pixel MKID array shown below.

Roadmap recognition of extra-zodiacal operational orbits for space astronomy, the SEP technology to achieve them cost effectively, and development of photon counting detectors for space flight application are astrophysics roadmap objectives we propose that can transform space astronomy to yield growth in mission science capability in an environment of long term downward budget pressure.



Clockwise from upper left: [a] The Zodiacal background in two inclined heliocentric orbits derived from Kelsall et al.[3] is shown relative to a zero inclination orbit at the Sun-Earth L2 point. Inset: Isodensity contours of the interplanetary dust cloud. Both orbits shown in Figure A extend outside of the reference contour shown; [b] A photograph of the ARCONS 2024 pixel MKID array; [c] A typical single photon signal with the ACRONS array; [d, e] The relative survey speed and sensitivity performance gain for two heliocentric orbit cases that are inclined wrt the ecliptic: 1 AU radius 30 deg inclination (blue) and 2 AU radius 15 deg inclination (green).

References:
[1] Greenhouse, M. A. et al. Breakthrough capability for the NASA Astrophysics Explorer Program: Reaching the darkest sky, Proc SPIE vol 8442, p14, 2012.
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[3] Kelsall, T., et al. The COBE diffuse infrared background experiment search for the cosmic infrared background. II. Model of the infrared background, ApJ 508, 44-78, 1998.