

## Miniature Lightweight X-ray Optics (MiXO) for Surface Elemental Composition Mapping of Asteroids and Comets

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**Introduction:** The elemental compositions of diverse planetary bodies such as asteroids and comets are of fundamental interest to planetary science in understanding the formation and evolution of the target bodies and the Solar System as a whole [1, 2]. Utilizing X-ray fluorescence unique to each atomic element, X-ray imaging spectroscopy is a powerful diagnostic tool to understand the chemical and mineralogical composition of the bodies. Near-target X-ray observations of planetary bodies so far, however, have been limited to those performed by simple collimator-type X-ray instruments due to heavy, bulky and expensive X-ray optics inadequate for *in-situ* missions [e.g. 3, 4]. We introduce a new Miniature lightweight Wolter-I focusing X-ray optics (MiXO) that enables compact, powerful imaging X-ray telescopes suitable for resource limited *in-situ* planetary missions.

**Technology & Performance:** Continuing advances in the electroformed Nickel replicated X-ray optics, combined with the Plasma Thermal Spray technology, now enable new lightweight metal-ceramic hybrid material for focusing X-ray optics [5]. In comparison to an alternative approach using micro-pore optics [e.g. 6, 7], the MiXO telescopes made of metal-ceramic hybrids are expected to excel by a large factor in virtually all major optics parameters including on-axis effective area (by  $\sim 3x$ ), grasp (overall throughput, by  $\sim 3x$ ), energy range (up to 15 keV) and angular resolution ( $< 30''$ , by  $\sim 16x$ ) under the same packaging volume and mass constraints [8].

High resolution imaging with MiXO can identify small regions with abundant organic or unusual elements. For relatively small targets including asteroids and comets, forgiving observing conditions allowed by high resolution and low background in MiXO can extend useful observing periods and thus increase a chance of new discoveries. The modular design of MiXO can be easily scaled from low-cost Explorer-class to large scale Flagship missions. As sample return becomes more desirable for future planetary missions, near-target X-ray observations by MiXO telescopes can aid the sample site selection and provide the context of the returned sample through high resolution elemental composition map of the entire target surface. MiXO will greatly enhance future planetary X-ray observations, making a quantum leap toward fulfilling the immense potential of X-ray imaging spectroscopy.

### References:

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