WHAT COULD BE LEARNED FROM PHASE CONTRAST X-RAY NANOTOMOGRAPHY ANALYSIS OF COSMIC DUST POTENTIALLY COLLECTED IN DEEP SPACE? Z. W. Hu, XNano Sciences Inc., P. O. Box 12852, Huntsville, AL 35815, USA (zwhu@xnano.org).

A gateway in cislunar space for next-step human exploration of the solar system will provide new opportunities for science research, including enabling unbiased collections of primitive cosmic dust particles for laboratory study. Cosmic dust particles, also known as interplanetary dust particles (IDPs), derive primarily from comets and asteroids [1]. They provide samples of primitive or the least altered fine-grained materials from the early solar system, some of which were either not incorporated or not preserved in common meteorites [2-3]. Cosmic dust particles studied to date are collected in the stratosphere as well as in polar regions and deep-sea sediments [1, 4-6]. These collected particles are the samples of primitive solar system bodies that have survived atmospheric entry (hence biased samples). They experienced varying degrees of heating during atmospheric entry, which complicates analysis (atmospheric entry heating and terrestrial contamination or weathering have been a limiting factor in realizing full scientific potential of the collected cosmic dust). Collecting cosmic dust in cislunar space would eradicate the drawbacks to collection in the terrestrial environment. Moreover, with a long-duration collector in the pristine space environment, pristine primitive cosmic dust particles from known sources could be harvested with a great size range, say, from submicrons to one hundred microns or larger. By using state-of-the-art and new laboratory instruments with unparalleled resolution and sensitivity, analyses of the pristine primitive cosmic dust particles collected in deep space would allow challenging questions to be uniquely answered about the early solar system and beyond. In this presentation, I will explore what could be learned from phase contrast X-ray nanotomography (PCXNT) study of cosmic dust to be potentially collected in cislunar space, based on new results obtained from porous IDPs [7].

Knowledge of the morphology and structures of the most primitive fine-grained cosmic dust particles at the 3-D nanoscale is key to understanding properties of the most fine-grained dust aggregates and grain aggregation in the protoplanetary disk (the crucial first step towards the formation of planetesimals and/or planets [8-9]) as we come to appreciate that cosmic dust contains samples of primitive or the least altered dust of the outer solar nebula. PCXNT enables bulk porous particles to be noninvasively visualized and analyzed morphologically and microstructurally in 3-D ~ 10 nm detail, which has resulted in new findings, including revealing an inherently fragile and intricately porous aggregate of submicron grains or clusters that are delicately bound together frequently with little grain-to-grain contact in 3-D space in CP IDP U2015-M-1 [7]. PCXNT study of the most primitive cosmic dust particles collected in deep space would enable the 3-D structures of protoplanetary fine-grained particles to be determined qualitatively or quantitatively, including 3-D pore structure and porosity, 3-D morphologies of pristine grains and their parent particles, grain size distributions, the spatial arrangements of grains, and grain-to-grain contacts. The new information would advance our understanding of the properties of the most primitive fine-grained solar system materials and yield in-depth insight into grain or cluster aggregation, the evolution of dust morphology, and early accretional processes. It would shed light on the properties of the protoplanetary disk. Our initial nondestructive 3-D mapping of pore structure of CP IDPs has demonstrated a viable new approach to probing dust and ice agglomeration at a fundamental level [7]. Pristine collections in cislunar space would provide an invaluable resource to address such questions as the sizes of icy or ice grains, the ratio of dust/ices [10], and the role of ices in growing larger aggregate particles [11].

In conclusion, collecting cosmic dust in deep space would provide unbiased samples of primitive solar system materials for laboratory study. Nondestructive analysis of 3-D structures and morphology of the most primitive fine-grained aggregates with PCXNT would advance our understanding of the properties of protoplanetary fine-grained particles and provide direct information about the formation of our solar system that may be unobtainable otherwise.

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