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Fragments from the Origins of the Solar System and our Interstellar Locale (FOSSIL): A Discovery Mission Concept

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Abstract

Among solar system objects visible to the unaided eye, only one has not yet been explored by a dedicated space mission: our zodiacal cloud. The cloud is made up of specks of dust, each a tiny time capsule from one of the solar system's most primitive bodies or our interstellar neighborhood. The dust provides a unique opportunity to learn about hundreds of comets and asteroids, which remains an impossible task for targeted missions with a small number of destinations. Sampling thousands of dust particles from our solar system's building blocks and interstellar space is the purpose of the FOSSIL mission (Fragments from the Origins of the Solar System and our Interstellar Locale) and the key to revealing our cosmic roots.

The FOSSIL Mission Concept

FOSSIL would be placed in an Earth-trailing orbit, carrying four state-of-the-art Dust Telescopes (DT) pointed anti-sunward to measure impacting dust particles' mass, composition, charge, and velocity vector. This approach connects decades of ground-based radar measurements of the speeds and directions of meteors from various sources, lacking compositional information, with decades of laboratory work on meteorites' compositions, similarly lacking dynamical information that would reveal their sources.

FOSSIL Instrumentation

Each DT consists of a Trajectory Sensor (TS) and an impact ionization reflectron-type time-of-flight (TOF) Composition Analyzer (CA). The CA has strong heritage from instruments already flown and in development: the Cosmic Dust Analyzer (CDA) onboard Cassini, the Lunar Dust Experiment (LDEX) onboard the Lunar Atmosphere and Dust Environment Explorer (LADEE) mission, and the Surface Dust Analyzer (SUDA) instrument for the upcoming Europa Clipper mission.

Summary

FOSSIL would determine whether the contemporary local interstellar cloud's dust has a composition consistent with the feedstock for the formation of the solar system, while resolving the longstanding conflict between interstellar dust masses measured in situ by Ulysses and those inferred from optical observations of the attenuation of the light from nearby stars. The mission would also sample for the first time a large and diverse set of comets and asteroids, inventorying the silicates, metals, and organics in our solar system's original building blocks.

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