

The Chemical Composition of Interstellar Dust in Light of the DESTINY⁺ Mission: A Novel Tool to Measure the Elemental Abundances and Ionization of the Local Interstellar Cloud

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The chemical composition of interstellar dust is directly linked to the depletion of elements in the gas phase of the interstellar medium (ISM), owing to the complementarity of elements in the solid and gas phases of the ISM. It has, therefore, been common practice to derive the elemental abundance of interstellar dust from the measured depletion of dust-forming elements in the gas phase of the ISM. The chemical composition of both solid and gas phases in the ISM would be a crucial factor for the evolution of the presolar molecular cloud, from which the Sun and the Solar System formed about 4.5 billion years ago. In particular, the organic and rocky components of interstellar dust would provide seeds for the origin of life and habitable planets.

On the one hand, the determination of elemental abundances in the solid and gas phases of the ISM is not a straightforward task if partially ionized, unless the ionization fractions of every elements are known a priori. This is exactly the case for the Local Interstellar Cloud (LIC) around the Sun, which is known to be a partially ionized warm cloud with an extension of several parsecs. On the other hand, recent technological advances in space missions have provided us direct information on the chemical composition of dust in the LIC by means of laboratory analyses (Stardust) and in situ measurements (Cassini).

The DESTINY⁺ Dust Analyzer (DDA) onboard DESTINY⁺ is a successor of Cassini's Cosmic Dust Analyzer (CDA) equipped with an impact ionization detector and a time-of-flight mass spectrometer. The DDA will measure the chemical composition of interstellar dust streaming into the inner Solar System from the LIC, similar to the CDA, but with an elevated performance in terms of mass resolution and sensitive area. We have analyzed astronomical data on the depletion of elements in the gas phase of the LIC and the ionization states of the elements, derived the elemental abundances of dust in the LIC from the depletion, and compared them with space mission data. We found that DDA's data on the chemical composition of interstellar dust will constrain the gas-phase abundances and ionization states of elements undetectable by remote astronomical observations. In this talk, we will demonstrate that the DDA is a novel tool to measure the composition and ionization of the LIC.

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