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Chemical Enrichment of the Solar System by Stellar Ejecta

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Abstract. Spectroscopic observations of evolved stars have shown signatures of aromatic and aliphatic compounds. This suggests that complex organics with chemical structures similar to those of insoluble organic matter (IOM) found in carbonaceous meteorites are made in stars. This raises the possibility that in addition to known pre-solar grains such as silicon carbide, organic star dust may also have traveled across the Galaxy to the Solar System.

Through remote and in-situ observations, astronomers and space scientists have discovered that organic molecules and solids are widely present in comets, meteorites, asteroids, interplanetary dust particles, and in planets and their satellites. Almost all biologically relevant organic compounds have been identified in the soluble component of carbonaceous meteorites (Schmitt-Kopplin *et al.* 2010). The insoluble organic matter (IOM) component in meteorites have structures similar to that of kerogen (Cody *et al.* 2011). The excesses in D, ^{13}C, and ^{15}N suggest that the IOM in meteorites could be of interstellar origin.

Recent infrared and submm-wave spectroscopic observations have found over 70 different kinds of gas-phase molecules, including cyanopolyyenes and acetylene, in the stellar winds of stars in the late stages of evolution. In the subsequent proto-planetary nebulae and planetary nebulae phases, complex organics with aromatic and aliphatic structures are formed (Kwok 2004, Kwok & Zhang 2011). Since the expanding circumstellar envelopes have dynamical life times of $\sim 10^4$ yr, these discoveries suggest that organics are made naturally by stars over very short periods of time. Through stellar winds, these organics are ejected into the diffuse interstellar medium and spread all over the Galaxy. Isotopic analysis of meteorites has identified several different kinds of inorganic (e.g., SiC) star dust, showing that stellar solid materials have reached the Solar System.

Observations of distant galaxies also show spectroscopic signatures of aromatic and aliphatic compounds. It is now evident the complex organics were made as early as 10 billion years ago during the early days of the Universe (Kwok 2011). If complex organics are indeed prevalent in the Universe, to what extent the Solar System, and by implication, the early Earth, have been enriched by organic star dust? This is an interesting question that deserves serious further studies.

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