The refractory fraction of sulfur and other elements in extrasolar systems

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We present results from a new method of measuring the partitioning of an element between volatile and refractory reservoirs in the inner few astronomical units of protoplanetary disks. This yields the first measurement of the bulk fraction of sulfur locked in extrasolar dust and planetesimals, and allows analogous measurements for other elements, of which we discuss zinc and sodium. These results place the elemental composition of solar system and extrasolar planetesimals in a broader context of planet-forming solids.

Sulfur is a major constituent of meteorites and planetary cores. It is also an important element in the atmospheric chemistry of several solar system planets, and is bio-essential on Earth. Its 50% condensation temperature in a solar composition mixture is ~680 K. While equilibrium condensation calculations predict sulfur is mostly locked in troilite (FeS), observations of the diffuse interstellar medium (ISM) suggest that sulfur is almost entirely in the gas phase. The gas-phase component of sulfur generally has a very low abundance in molecular clouds and protoplanetary disks, however, while CI chondrites have a slightly super-solar S/Si ratio, suggesting that sulfur returns to a refractory form somewhere along the path from the ISM into planetary systems.

We investigate the refractory fraction of S in disks, using diffusively mixing young stars which accrete from their protoplanetary disks. A treatment of the stellar mixing processes allows us to use the stellar surface composition to determine elemental abundances in the accreting material. Our previous work showed that these abundances correlate with the gas-to-dust ratio in the inner disk. We now use Markov Chain Monte Carlo techniques on a sample of young stars to measure the fraction of sulfur, zinc, and sodium locked in large dust particles. For sulfur, we find this to be 87±6 %. We discuss the likely carrier species, as well as implications for solar system solids, the gas-phase ISM, and planetary cores and atmospheres.

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