Sulfur in Dust

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Seven elements have the potential to be the dominant constituents of interstellar dust: C, N, O, Mg, Si, Fe and S. These are the non-noble gases with cosmic abundances greater than 10^{-5} that of hydrogen (the next most abundant element, Al, has less than 14% the abundance of S). Studies have, in fact, shown that C, O, Mg, Si and Fe are dominant elements in dust by number and by mass (Jenkins 2009). N is not a major constituent of dust, but this is explained by its inclusion in the highly stable gas form of N_2 (Gail & Sedlmayr 1986). Of the principal dust-composition candidates, only the role of sulfur remains enigmatic.

Interstellar grains, identified by their isotopic compositions, recovered from within interplanetary dust particles (IDPs) embedded in meteorites, show that S is often incorporated into interstellar silicates (Bradley 1994, Bradley & Ireland 1996, Bradley et al. 1999). In fact, these grains, GEMS (glass with embedded metals and sulfides), have sulfur-to-silicon ratios that are 60 - 80% of the solar value (Bradley 1994). Further support for the interstellar origin of GEMS comes from the identification of their infrared spectral characteristics that match what is seen in interstellar environments (Bradley et al. 1999). The combined evidence makes a strong case for GEMS, and therefore sulfur, being a major component of the interstellar grain population.

It is therefore surprising that the best measurements of interstellar abundances, those determined from high-resolution *HST* observations, suggest that sulfur is not depleted into interstellar grains (Spitzer & Fitzpatrick 1993, 1995; Sofia, Cardelli & Savage 1994; Fitzpatrick & Spitzer 1994; Savage & Sembach 1996; Howk et al. 1999; Welty et al. 1999). It is only very recently (Jenkins 2009; White & Sofia 2011) that there has been a suggestion, based on high-quality interstellar abundance measurements, that there may be large S depletions along some sight lines. Martin (1995) summarizes the importance of determining whether sulfur-bearing grains are in the interstellar medium: "Understanding GEMS would then hold promise of fresh insight into diverse problems concerning interstellar grains, such as their origin and processing in the interstellar medium, differential depletion of the elements, grain alignment, the effective dielectric function of dirty silicates, and the infrared spectra of amorphous silicates."

This uncertainty of sulfur's incorporation into dust does not only affect the study of sulfur. It is so well accepted that S is undepleted in the gas-phase ISM that authors are using sulfur as a proxy for H when they are deriving depletions for other elements. This is such a potential problem that Jenkins (2009) says about sulfur: "A study of the depletion behavior of sulfur is especially important, since many studies of gas in both our Galaxy and very distant systems have relied on this element as a standard for what should be virtually zero depletion. We need to re-examine whether or not this is true." Jenkins (2009) further suggests that "We could certainly benefit from some future, far more comprehensive survey of sulfur abundances."

We present our initial results for S depletions in the neutral ISM based on all of the available HST sight lines (40 total) with appropriate observations. Our results show that S is an important dust component. As such, it has implications for extinction models and for abundance studies (Galactic and extragalactic) that rely on S as a proxy for H when determining dust compositions.