Developing ISM Dust Grain Models with Precision Elemental Abundances from IXO

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Abstract

The exact nature of interstellar dust grains in the Galaxy remains mysterious, despite their ubiquity. Many models exist, based on available IR-Lamda data and elemental compositions. However, the abundances, which are perhaps the most enigmatic constants, are not well known; modern models must use proxies in the absence of direct measurements for the diffuse interstellar medium (ISM). Recent revisions of these proxy values have only added to confusion over which is the best representative for the diffuse ISM, and highlighted the need for direct, high-signal-to-noise measurements from the ISM itself. The International X-ray Observatory’s superior facilities will enable high-resolution elemental abundance measurements. We will show how these results will measure both the overall ISM abundances and challenge dust models, allowing us to construct a more realistic picture of the ISM.

IXO will be able to examine abundances in different environments in the ISM, thus opening a window on the study of grain evolution and cycling between diffuse and dark clouds. In Fig. 4, we have plotted the percent error of abundance measurements for a source, modeled again as X Per, with exposure times of 50 ks and Chandra and XMM, and 20 ks and IXO. We used the solar abundances of Wilms et al. (2001) and set Ne to different values: 5x10^12, 5x10^13, and 5x10^14 cm^-3. The uncertainties for Chandra and XMM tend to be around 20% higher, even after relatively diffuse sightlines as the density increases, the uncertainty goes up, to 100% in many cases. Among very dense sightlines (Ne = 5x10^14 cm^-3), IXO cannot detect any of these elements given the exposure time. In stark contrast, the uncertainties with IXO are far lower, less than 3%, for both diffuse and dense sightlines.

IXO will provide us with high precision data, over a wide range of environments, that has not been available with previous missions. By providing us with high quality abundance maps both total and gas-phase, over a wide range of environments, IXO will revolutionize interstellar dust modeling.

The Importance of IXO

High-signal-to-noise measurements coupled with multiwavelength data along diffuse ISM sightlines are crucial to building comprehensive ISM models. IXO will provide high quality observations of the absorption edges of dust-forming elements, in short exposure times. Fig. 2 compares modeled spectra from Chandra and IXO of the nearby M82 XPer (modeled with a power law Nv = 2x10^13 cm^-3; y = 1.1; flux = 10^-16 erg cm^-2 s^-1). Exposure times are indicated. Even assuming the very low solar abundances of Wilms et al. (2000), IXO (10 ks) can recover Mg, Si, and Fe abundances to better than 10% (Table I).

IXO-large scale surveys will greatly increase the number of sightlines where such spectroscopy can be done. Over 1001 sources have fluxes high enough to allow determination of the abundances to O, Mg, Si, and Fe to within 20% uncertainty; this is sufficient to distinguish between the models (Table 2). Two of these sightlines are plotted in Fig. 3. With numerous bright Galactic sources, this will also provide invaluable information on the chemical abundance of the ISM, and chemical enrichment. Further, IXO's exquisite resolution will allow us to examine X-ray absorption edge fine structure, which will let us determine the chemical states of the elements in, thus imposing further constraints on grain composition.