DEVELOPING METHODS TO INCORPORATE CALIBRATION UNCERTAINTIES IN DATA ANALYSIS

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We have made considerable progress in our efforts to incorporate calibration uncertainties in data analysis this year. The method we have developed is robust and general and can be used to estimate the magnitude of systematic errors that affect the derived values of spectral model parameters for low-resolution spectra. Because such uncertainties are usually ignored during spectral fits, the error bars derived for model parameters are always underestimated. Incorporating them directly into spectral analysis with existing analysis packages such as Sherpa and XSPEC is not possible without extensive case-specific simulations, but it is possible to do so in a generalized manner in a Markov-Chain Monte Carlo (MCMC) framework. We have implemented such a scheme within BLoCXS, an advanced Bayesian algorithm to analyze low counts X-ray spectra in the context of estimating the effect of ACIS effective area uncertainties first described by Drake et al. (2007, SPIE, v6270, p49). Much of the implementation work was carried out by our postdoc Hyunsook Lee under the direction of the PI.

The progress in our work was reported at the proceedings of the Chandra Calibration Workshop, "Incorporating Effective Area Uncertainties into Spectral Fitting", by Kashyap et al., 2007, CCW 2007.2 -- see http://cxc.harvard.edu/ccw/proceedings/07_proc/presentations/kashyap/

That presentation shows that the method we have developed to take into account errors in effective areas within spectral fits does work, and produces results that are, first, consistent with the brute force methods first tried by Drake et al., and second, faster in execution by more than a factor of 100. Whereas the original brute force calculations take as much as half a day to derive symmetrical-sided errors due to statistical and systematic effects on a given spectrum, the same calculation can now be carried out in about 10 minutes to produce a full-fledged posterior probability distribution (i.e., even asymmetrical error bars can be properly characterized). The method is applicable directly to any spectral model in all parts of the corresponding parameters space. Because no Gaussian approximations are made in calculating the error bars, and the full posterior probability densities of the parameters are constructed, the derived parameter bounds are optimally sized. The method is also fast and is easily generalizable to accounting for the systematic uncertainties in any type of multiplicative factors.

We plan to present updates to this work in two forthcoming conferences: AAS-HEAD, at the end of March 2008, where we intend to show the application of the method to real spectra, and at SPIE, in June 2008, where we intend to propose a file standard definition that will allow the systematic uncertainties in the effective areas of ANY instrument to be seamlessly incorporated in popular analysis packages such as XSPEC and Sherpa.

We have also been working on carrying out the same type of analysis with spectral response matrices (RMFs), and have achieved some major breakthroughs in dimensionality reduction and ease of reconstruction. There are different schemes that can be used to do this, including both Principal Components analysis similar to that used with effective areas, as well as multiscale modeling with structures that are similar to wavelets (see, e.g., Connors & van Dyk, 2007, SCMA IV, in press).