Dust Busters: The Effects of Dust Scattering on Observations of X-Ray Binaries

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Black hole X-ray binaries contain a black hole that accretes gas from a companion star, producing bright X-rays. By fitting the X-ray spectra with astrophysical models, we can estimate key parameters such as the black hole's mass and spin. However, the observed spectrum is modified on its way to the telescope by interstellar dust, which scatters and absorbs photons and can bias spectral fits if not modeled properly. There are several x-ray telescopes that collect spectral data from x-ray binaries; each has advantages and disadvantages. The Swift X-ray telescope in the Windowed Timing (WT) mode is an excellent source of data with a fast refresh rate, 1D imaging that enables scattering modeling, and an energy range well suited for observing x-ray binaries. The standard spectral analysis software, XSPEC, includes the xscat model, which accounts for dust scattering. However, the xscat model is inconsistent with SWIFT/XRT data. First, it assumes an extraction-region geometry that does not match the way SWIFT/XRT data are actually extracted. Second, bright sources are observed in WT mode to reduce pileup, yet residual pileup remains and is removed during data cleaning by excising the central region. xscat ignores this excision, biasing the model calibration. The goal of this project is to resolve this mismatch by developing an improved model, xscatXY, that uses a consistent extraction geometry and accounts for the removed section of the data. Addressing these key systematic biases will make SWIFT data more suitable for black hole spin estimation. This work demonstrates how instrument-specific modeling can allow for precise parameter fitting using data that was previously considered unsuitable. xscatXY is planned to be incorporated into XSPEC, which is maintained by NASA.

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