Determining the Dust Property with the X-ray Scattering Halo

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X-ray photons, emitted by X-ray sources, are absorbed and scattered by dust grains when they travel through the interstellar medium. The scattered photons within small angles results in a diffuse X-ray "halo". Therefore, the scattered X-ray photons carry the information about dust distribution, dust grain model, scattering cross section, and the distance of the X-ray source. Those photons also take longer time than the unscattered photons to reach the observer. Using a cross-correlation method, we study the light curves of the X-ray dust scattering halo of Cyg X-1, observed with the Chandra X-ray Observatory. Significant time lags are found between the light curves of the point source and its halo. This time lag increases with the angular distance from Cyg X-1, implying a dust concentration at a distance along the line of sight (LOS) of 2.0 kpc from the Earth. By fitting the observed light curves of the halo at different radii with simulated light curves, we obtain a width of $\triangle$L=33 pc of this dust concentration. The origin of this dust concentration is still not clearly known. The time lag of Cyg X-3 reveals a distance of 6.7 kpc from the point source to us. Combining the derived dust distribution from the cross-correlation study with the surface brightness distribution of the halo, we conclude that the two commonly accepted models of dust grain size distribution need to be modified significantly. We also study dust properties with the expanding X-ray rings from dust scattering of X-rays of distant gamma-ray bursts.

References

[1] James W. Overbeck, *the Astrophysical Journal.* **141**, 864 (1965).
[2] Zhixing Ling, Shuang Nan Zhang, Jingen Xiang and Shichao Tang, *the Astrophysical Journal.* **690** 224 (2009).
[3] Zhixing Ling, Shuang Nan Zhang and Shichao Tang, *the Astrophysical Journal.* **695** 1111 (2009).