AN X-RAY SURVEY OF OB ASSOCIATIONS IN THE LARGE MAGELLANIC CLOUD

QINGDE WANG AND DAVID J. HELFAND
Columbia Astrophysics Laboratory
538 West 120th Street
New York, NY 10027

ABSTRACT. Based on *Einstein* IPC data, we have completed a census of X-ray emission from and around OB associations in the LMC. In addition to an apparent correlation of young, X-ray bright supernova remnants with recent star formation regions, we detect diffuse X-ray emission from over two dozen other associations; luminosities in the 0.16 – 3.5 keV band range from $\sim 3 \times 10^{34}$ (the detection threshold) to $\sim 10^{36}$erg s^{-1}. The mean X-ray luminosity of the $\sim$ 50 undetected associations is $\sim 10^{34}$erg s^{-1} and the emission from all associations contributes $\sim$ 4% to the total diffuse X-ray emission from the galaxy. Implications of this survey for ISM bubble evolution is discussed.

In a recent paper by Wang *et al.* (1990) we have summarized previous work on *Einstein* observations of the LMC, presented a revised discrete X-ray source catalog based on all available IPC images, and described a series of calibration and contamination-removal algorithms necessary for the study of diffuse X-ray emission with the IPC. In a series of papers (Wang and Helfand 1990a,b,c), we have presented detailed studies of bright X-ray emission regions: the 30 Doradus Nebula and the supergiant bubble LMC 2, as well as a general study of the X-ray properties of the OB associations. The following is a brief description of our X-ray survey of the diffuse X-ray emission from the OB associations.

Among 86 associations covered in the survey, 22 discrete X-ray sources are found which fall within the boundaries of 17 OB associations. Among these are six OB associations — LH 53, 75, 83, 88, 90 and 99, each of which apparently contains one of the 28 X-ray emitting SNRs in the LMC (also see Chu and Kennicutt 1988). The expected chance coincidence rate is < 1. It will be interesting to study these remnants in detail to determine how their location in or near the low-density cavities created by their parent association will affect their evolution.

Significant diffuse X-ray emission is detected from the vicinities of LH39, 47, 54, 60, 63, 76, 81, 87, 90, and 104. Their X-ray fluxes fall in a narrow range of .01 – 0.05 IPCct s^{-1}, corresponding to X-ray luminosities of $\sim 10^{35}$ to $\sim 10^{36}$erg s^{-1}. All of these associations are relatively compact, presumably young clusters with diameters < 90 pc and a median stellar content of 30, somewhat higher than the average of $\sim$ 20 stars per association for the sample as a whole.

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Emission from the associations such as LH47, 54, and 90 has been resolved; they exhibit shell-like X-ray morphologies which generally follow the Hα-emitting gas. These X-ray sources are both larger and fainter than those identified as SNRs, and show a rough correlation between source intensity and the spectral hardness of the emission.

In an attempt to find lower surface brightness, more extended X-ray emission in the vicinity of OB associations, we searched the remaining 69 associations with two larger source-searching apertures. Maintaining our 4σ detection threshold as used in our $2'.5$ aperture discrete source search (Wang *et al.* 1990), we find six additional detections with a $6'$ aperture and fifteen with an $8'$ aperture.

The integrated X-ray count rate from $8'$-diameter circles centered on each of these 69 OB associations is 0.33 ct s^{-1}. The integrated emission from the detected discrete source associations excluding the SNRs, a foreground star, and LMC X-1 is 0.32 ct s^{-1}, providing an upper limit (owing to possible chance coincidences) to the total contribution of individual OB associations to the diffuse X-rays from the Cloud: $\lesssim 0.65$ ct s^{-1} or $\sim 4\%$ of the total diffuse emission. For the remaining (undetected) 53 associations, we find an average flux of $\sim 2 \times 10^{-3}$ct s^{-1} per association corresponding to a mean luminosity of $\sim 2 \times 10^{34}$erg s^{-1}. This compares with an expected stellar contribution from 20 O9 stars per cluster of $\sim 5 \times 10^{32}$erg s^{-1}.

As we have compiled the first census of the X-ray properties of OB associations in the Cloud, we have begun to combine the X-ray information with observations at other wavelength bands in order to explore the evolution of giant bubbles.

We have calculated a composite X-ray spectrum of a wind-driven bubble and shown that very soft X-rays emitted from the conductive layer at the edge of the bubble dominate the bubble's cooling; this low energy radiation is almost entirely absorbed on the way to the Earth. The expected X-ray flux in the IPC broad band is typically below the observed values by a factor larger than 10. The two brightest bubbles, N44(LH47) and N157C(LH90), also have the hardest X-ray spectra observed; a fit of their combined spectral data to thermal plasma models (Raymond *et al.* 1977) results in a temperature range of ~ 0.8 to 1.8 keV (with a 90% significance level). Their high X-ray luminosities and hard X-ray spectra require either wind-driven bubbles evolving in a dense medium ($\gtrsim 10^2 \mathrm{cm}^{-3}$) or SNR-filled-bubbles. Most of the other association detections also appear to require X-ray emission enhanced over the level predicted by simple bubble models. SNRs hitting the dense shells of young (typically several 10^6 years old) bubbles may produce such enhanced X-ray emission.

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