DISCOVERY OF A COMPACT SOURCE IN AN LMC SNR DEM L241

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ABSTRACT

We report on an *XMM-Newton* observation of the supernova remnant (SNR) DEM L241 in the Large Magellanic Cloud. In the soft band image, the emission shows an elongated structure, like a killifish (Head and Tail), with a central point source, named as XMMU J053559.3−673509 (Eye). The Eye's spectrum is well reproduced with a power-law model with the photon index of 1.57 and the intrinsic luminosity of 2.2×10^{35} ergs s^{-1} in the 0.5–10.0 keV band. The source has neither significant coherent pulsations nor time variabilities. Its luminosity and spectrum remind us that the source might be a pulsar and/or a pulsar wind nebula in DEM L241. The spectra of Head and Tail are well reproduced by an non-equilibrium ionization plasma model of kT = 0.4–0.6 keV. The over-abundant Ne and under-abundant Fe might suggest that the progenitor of DEM L241 is a very massive star.

Key words: supernova remnants, X-rays: individual (DEM L241), X-rays: individual (XMMU J053559.3−673509) .

1. INTRODUCTION

Supernovae and supernova remnants (SNRs) shape and enrich the chemical and dynamical structure of the interstellar medium and clouds. Moreover, SNRs are believed to be cosmic ray accelerators around their pulsar and pulsar wind nebula (PWN), and/or shock fronts. The Large Magellanic Cloud (LMC) is the best galaxy for the systematic study of SNRs, thanks to the known distance (50 kpc; Feast, 1999) and small absorption column. In the LMC, we pointed out DEM L241 (0536−67.6), which was identified by Mathewson et al. (1985) and reported hard X-ray emission with *ASCA* (Nishiuchi, 2001), implying that this SNR is a cosmic-ray accelerator. However, Nishiuchi (2001) could not conclude that due to the lack of spatial resolution. Therefore, we observed this SNR with better spatial resolution of *XMM-Newton*. The total exposure is 45 ks for MOS and 43 ks for pn, respectively. The datails analysis and discussions are in Bamba et al. (2005).

2. RESULTS

Figure 1 shows the *XMM-Newton* MOS 1+2 images of DEM L241 in the (a) 0.5–2.0 keV and (b) 2.0–9.0 keV bands. In the soft band image, we can see a diffuse structure elongated from southeast to northwest with the size of $\sim 1.5' \times 3'$, corresponding to 22 pc×44 pc at 50 kpc. The shape is like a killifish, with double peaked feature on its "Head" and "Tail". In addition to the body of the fish, there is a point source like an "Eye" of the fish. On the other hand, only Eye can be seen in the hard band image. We found no candidate of the counterpart of Eye in the SIMBAD database, and named it as XMMU J053559.3−673509. The possibility is only 0.11% that Eye is a background AGN accidentally in the SNR region following the $\log N$—$\log S$ relation of AGNs derived by Hasinger et al. (1998). Therefore, we concluded that the Eye is in DEM L241. The upper-limit of the source size is 1.0 pc with the assumption that the distance to Eye is 50 kpc.

The spectrum of Eye is hard and has no line-like structure, and well fitted with an absorbed power-law model. The best-fit photon index (Γ) is 1.57 (1.51–1.62), and the intrinsic luminosity is 2.2×10^{35} ergs s^{-1} in the 0.5–10.0 keV. The central position and hard spectrum may indicate that Eye is a pulsar and/or a pulsar wind nebula (PWN) of DEM L241. We searched for but could not find any coherent pulsations and time variabilities. If Eye is a pulsar and/or a PWN, it belongs to the bright and hard class (Gotthelf & Olbert , 2002).

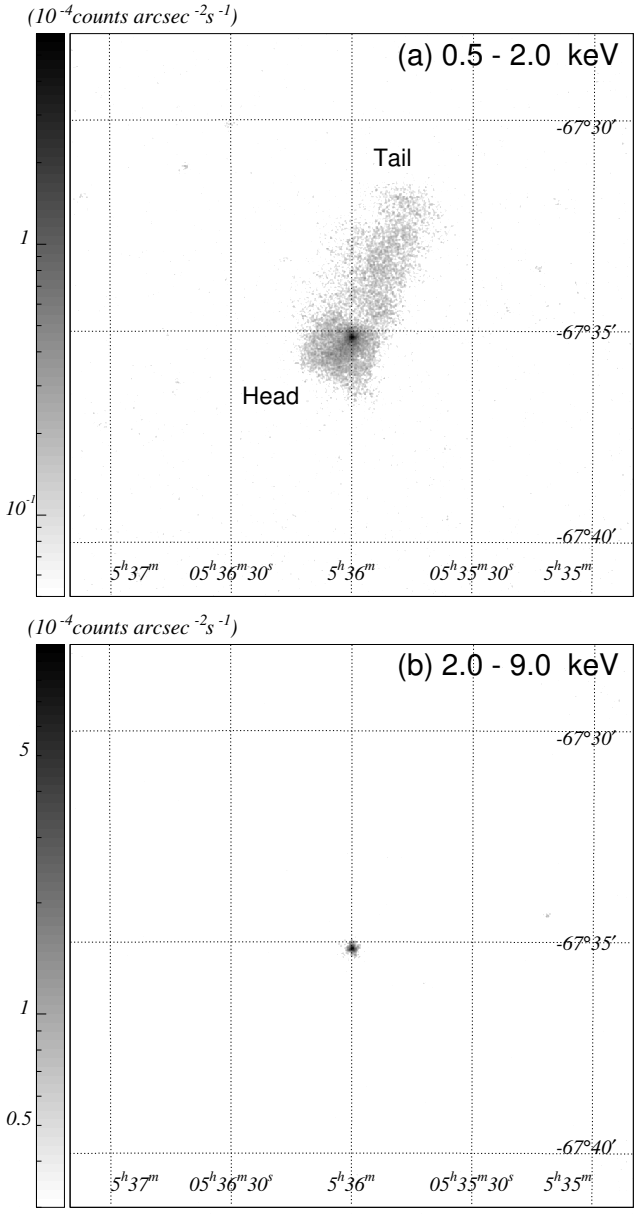

Figure 1. MOS 1+2 images in the (a) 0.5–2.0 keV and (b) 2.0–9.0 keV bands.

Table 1. Best-fit parameters for the Head and Tail

Parameters	Head	Tail
kT_e [keV]	0.54 (0.46–0.57)	0.43 (0.38–0.50)
$n_e t_p$ [10^{11}cm^{-3}s] ..	2.4 (1.9–4.3)	3.4 (2.1–5.2)
[Ne/H]	0.64 (0.60–0.69)	0.58 (0.54–0.63)
[Si/H]	(<0.05)	(<0.07)
[Fe/H]	0.09 (0.08–0.10)	0.08 (0.07–0.09)
$E.M.$ [10^{58}cm^{-3}] ..	2.5 (2.2–3.0)	2.1 (1.4–2.8)
$N_{\rm H}$ [10^{21}cm^{-2}] ...	4.2 (3.3–5.2)	1.6 (0.6–2.3)
Flux†	3.2×10^{-13}	3.6×10^{-13}

†: In the unit of ergs s^{-1} cm^{-2} in the 0.5–10.0 keV.

The Head and Tail emission have, on the other hand, soft and line-rich spectra. Both are well fitted with a non-equilibrium ionization collisional plasma emission model (Borkowski et al., 2001) ver. 2.0 as seen in Table 1. The temperature is 0.4–0.6 keV, typical value of thermal SNRs. The over-abundant Ne and less-abundant Fe relative to the average LMC value (0.3: Russell & Dopita , 1992) indicate that the progenitor of DEM L241 is a very massive star. The estimated total plasma mass ($\sim 200 M_{\odot}$) and the thermal energy (5×10^{50} ergs) also suggest the massive star origin, together with the existence of the hard and bright central point source, Eye, and the OB star association, LH 88 (Chu & Kennicutt, 1988).

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