ARE THE SUPERNOVA REMNANTS OF THE LMC IN THE ADIABATIC PHASE?

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1. INTRODUCTION. A catalog of supernova remnants (SNRs) observed in the soft X-ray band 0.15-4.5 KeV by the imaging instruments on board the Einstein Observatory has been recently published by Mathewson et al.(1983). One of the conclusions in their paper is that SNRs in the LMC appear to evolve to large diameters much faster than predicted by the adiabatic expansion theory (Sedov 1959). This is based on the observed cumulative number-radius (N-R) relation that for the remnants in the LMC turns out to be approximatively linear. As suggested by Mathewson et al.(1983),a linear N-R relation can be obtained assuming a population of SNRs in the free-expansion phase (phase I,Woltjer 1972) expanding in a homogeneous medium. In the following we show that the X-ray surface brightness as a function of linear radius (Σ-R diagram) and the N-R relation can be alternatively explained assuming that the SNRs in the LMC are in the adiabatic phase.

2. THE Σ-R DIAGRAM. In Figure 1 we show the surface brightness-radius relations derived from our NE-hydrodynamical models. Each evolutionary track is characterized by the value of the fundamental parameter $\eta = n_o^2 E_{51}$. For the sake of simplicity,tracks are labelled with the value of the interstellar density n_o. T_S ranges from about 10 to 0.2 keV. The η=1 track has been followed down to 0.02 keV. The hydrodynamical models are allowed to radiate since the beginning of their evolution. The surface brightness has been computed using metal abundances $\{M\}=0.3\{M\}_{\odot}$. As discussed in detail by Fusco-Femiano and Preite-Martinez (1983),it is possible to define from a theoretical point of view the expected location in the Σ-R plane of adiabatic remnants expanding in IS media of different densities. No adiabatic remnant can be found to the left of the line M=10 in Figure 1, no remnant,either in the adiabatic or in the radiative phase,can be found to the right of the line labeled $(\Sigma\text{-R})_{max}$. The overlap between the observational and the theoretical strip in Figure 1 can be taken as an indi-

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cation that (i)the remnants are indeed in adiabatic or later evolutionary phases,and (ii)in the LMC there is a variety of possible environments in wich SN explosions can occur,with a large spread of IS densities (Long et al. 1981),possibly larger than that in our set of models.

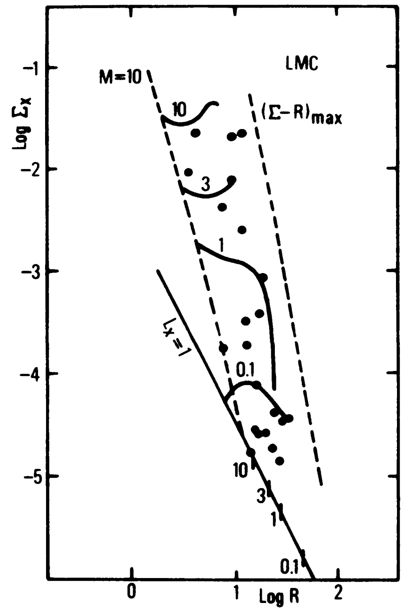

Figure 1. Surface brightness versus radius.

3. THE N-R RELATION. The cumulative number-radius relation has been redefined including all the sources listed in the survey except the three crab-like remnants (Figure 2). The N-R relation expected from a population of SNRs in adiabatic expansion in a homogeneous medium,$N \propto R^{2.5}$ (dashed line in Figure 2),is clearly inconsistent with the observed data. If we consider,though, that the ISM is not homogeneous,we are able to satisfactorily reproduce the shape of the observed N-R relation. Indeed,applying the Sedov's similarity solution,the number of remnants up to radius R is also an explicit function of the ambient density n :$N(R)=t(R,n)/\Delta t$ where Δt is the time interval between SN explosions,and $E_{51}=1$. We further introduce a possible dependence of Δt on n :$\Delta t \propto n^{-\alpha}$. As shown in Figure 2,even with $\alpha=0$ the N-R relation is much flatter than the relation expected for SNRs expanding in a homogeneous ISM. A slight dependence of Δt on the density (α in the range 0.0-0.5)can explain even the flattening at large radii (R>20pc). If this flattening is a real effect,it cannot be easily explained assuming that remnants are in free expansion. In other words,the shape of the N-R relation could turn out to be the stronger argument in favour of the adiabatic-expansion hypothesis.

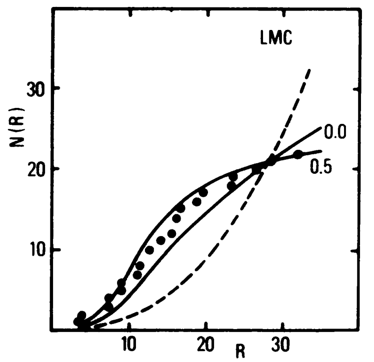

Figure 2. Cumulative number versus radius.

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