Chandra Observation of RCW 89 at Two Epochs

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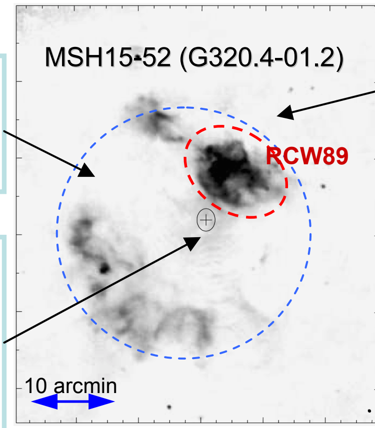
Abstract

We present a *Chandra* observation of the HII region RCW 89 in Dec 2004. RCW89 is part of the radio shell supernova remnant MSH 15-52 which contains a 150 ms young pulsar PSRB1509-58. Comparing with the X-ray image taken by Chandra in Aug 2000, we found that each plasma clouds in RCW89 have moved outward from the SNR center. The velocity of the radial motion is ~ 5600 +/- 3700 km s^{-1}. This result agrees with the scenario in which the plasma clouds in RCW 89 are the SN ejecta from the progenitor of the pulsar.

1. Introduction

Shell type SNR MSH15-52
- D = 5.2 kpc
- Age = 6 ~ 20 kyr
- Bilateral radio shells [1]

Energetic young pulsar PSR B1509-58
- Period = 150 ms
- pulsar age = 1700 yr
- L_{spin} = 1.8x10^{37} ergs s^{-1} [3]
- Crab like synchrotron nebula



8cm radio image by ATCA from [2]

The H-II region RCW89
- Radio: non-thermal continuum [2]
- Optical: HII and several forbidden lines ([NII] [OII,III] [NaI] [CaII] [SII] [FeII] [NiII]) [4]
- X-ray: NEI plasma + synchrotron [5]

Some questions remain unresolved…
- the energy source of thermal plasma
- the origin of the thermal plasma
- discrepancy in age between the pulsar and the SNR

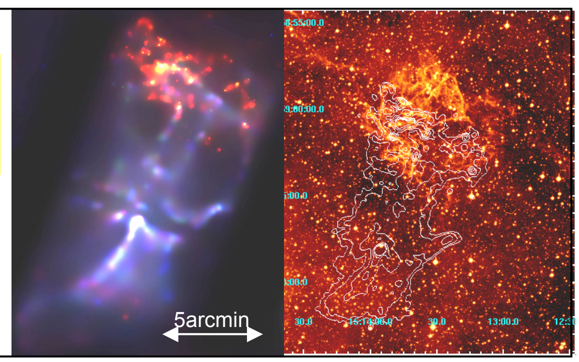
RCW 89 holds the key to solve the problems.

2. Observations

Epoch	Aug 2000	Dec 2004
Detector	ACIS-I	ACIS-S
Exp. time	19 ks	30 ks
Aim point	B1509-58	RCW89

*The time interval between the two observation is ~ 4.3 yr.

Our new observation revealed filament structure which seem to be associated with the optical filaments.

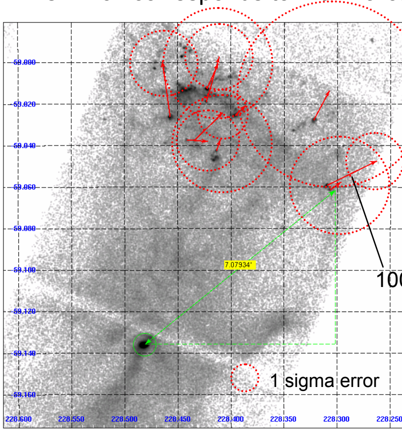


Left : the X-ray image by Chandra (R:0.4-1.2, G: 1.2-2.0, B: 2.0-10.0 keV)

Right: Hα image and X-ray contour (Super COSMOS H-alpha Survey [7])

3. Secular motion

The figure shows the direction of the each cloud in RCW 89. The lengths of the arrows represent the 50 times amplified travel distances of the clouds. We see that the clouds moved radially from the pulsar. The average of the radial velocity is **~5600 +/-3700 km/s**. The fastest one moves at 10000 +/- 5000 km/s which corresponds to ~ 0.41arcs/yr.



*The past radio observations show that the proper motion of the pulsar is very small, less than 190 marcs/yr [2],[3]. Thus we use the pulsar as a reference point. The positions were determined by two dimensional Gaussian fitting. In the calculation we using the PSF image created by *CIAO3.2* as the convolution kernel.

4. Discussion

(1) What accelerates the clouds? Pulsar wind or SN?

We examine the pulsar wind drive.

$$\Delta v = \int_{t_0}^{t} \frac{S}{M}\frac{\dot{E}(t)}{4\pi R^2 c}dt = 0.87 << 5600\,[\mathrm{km\,s^{-1}}]$$

where R (~7') is the distance between the pulsar and the plasma cloud, r (~5") the radius of the cloud, S the cross section of the cloud, M (10^{31}g)the mass of the cloud. (We set the time t_0, when the pulse period was 20ms.) The obtained velocity variation is much smaller than observed velocity 5600 km/s. We therefore conclude that the plasma clouds are accelerated by SN.

(2)Transverse time

Assuming uniform motion of the ejecta we constrain the transverse time.

$$\Delta t = \mathrm{R} / 5600\mathrm{km\,s^{-1}} \approx 1800\ \mathrm{yr}$$

This timescale corresponds to the pulsar 's characteristic age 1700 yr and is consistent with the scenario in which the SNR and the pulsar are originated in the same progenitor star. The rapid expansion of the SNR requires the low density ISM or the unusual powerful SN explosion as suggested by [4].

References

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[7]http://www-wfau.roe.ac.uk/sss/halpha