New high-frequency radio observations of Cygnus Loop SNR

Sara Loru - Astrophysical Observatory of Catania
Summary

- The radio spectra of SNRs
  - Single-dish observations up to high-frequencies
  - Characterization of the Cygnus Loop radio spectrum
- Conclusion and work in progress
A spectral index steepening is expected in evolved SNRs

\[ S = \nu^{-\alpha} \]

A possible spectral radio steepening allow us to assess the high energy tail of the electron distribution
Investigating SNR spectral features

Sensitive high-resolution images of SNRs above ~10 GHz are lacking and are not easily achievable.
SNRs observations with the Italian Radio Telescopes

Only single-dish telescopes can perform sensitive radio continuum observations of large sources at high frequencies.
Integrated spectrum of W44

- 1.5 GHz
- 7.0 GHz
- 21.4 GHz

Maximum energy of the electron distribution in the 6–13 GeV range

Spectral index break at $15 \pm 2$ GHz

See Pellizzoni’s poster S4.11

Loru et al. 2019

Egron et al. 2017

SRT early science project S0009
Integrated spectrum of IC443

See Pellizzoni’s poster S4.11

- 1.5 GHz
- 7.0 GHz
- 21.4 GHz

Spectral model proposed by Onić et al. (2017):

Egron et al. 2017

Loru et al. 2019

SRT early science project S0009
Cygnus Loop SNR

- The two shells show different polarization properties
- Variations of the spectral index from the outer shock fronts and the central faint regions

Uyanker et al. 2002

Han et al. 2013
Cygnus Loop SNR

Unexplored frequency range

Planck et al. 2016
Cygnus Loop SNR at 8.5 GHz

- 83 observing hours with the Medicina Radio Telescope (Project 14-17)
- Resolution: 2.5’
- Flux density: 54 ± 4 Jy

Loru et al. in prep
Integrated spectrum of Cygnus Loop

Spectral index $= 0.53 \pm 0.01$

Our measurement rules out any spectral steepening up to high radio frequencies

The highest frequency where the Cygnus Loop SNR was observed so far with high-resolution
Cygnus Loop with the Sardinia Radio Telescope

Our goal: Perform high-frequency and polarimetric investigations of the north and south shells

- Observations between 2018 December and 2019 May (Project 22-18)
- Frequencies: 7.0 GHz (C-band) 20 GHz (K-band)
North-bright filament of Cygnus Loop at 7.0 GHz

Flux density:
- $8.4 \pm 0.7$ Jy at 7.0 GHz
- $7.7 \pm 0.5$ Jy at 8.5 GHz

Loru et al. in prep

Preliminary work
North-bright filament of Cygnus Loop at 20 GHz

Loru et al. in prep

Preliminary work
North-bright filament of Cygnus Loop at 18.7 GHz

**Gamma-ray studies**

Spectral break in the cosmic-ray energy spectrum: 1-10 GeV

Implying a synchrotron spectral break at: 0.3-28 GHz

The determination of the spectral break frequency allow us to constrains the maximum energy of the accelerated cosmic-ray electrons and the magnetic field in the SNR shock regions.

**Gammaray studies**

Implying a synchrotron spectral break at: 0.3-28 GHz

The determination of the spectral break frequency allow us to constrains the maximum energy of the accelerated cosmic-ray electrons and the magnetic field in the SNR shock regions.
Conclusions and future work

- The high-frequency radio observations of evolved SNRs allow us to assess the maximum energy of accelerated CRs and magnetic field strength in the evolved SNRs.

\[ E_{CRs} = 14.7 \left( \frac{\nu_{GHz}}{B_{\mu G}} \right)^{\frac{1}{2}} \text{ GeV} \]  
(Reynolds 2008)
Conclusions and future work

- The high-frequency radio observations of evolved SNRs allow us to assess the **maximum energy** of accelerated CRs and **magnetic field strength** in the evolved SNRs.
- Perform the characterization of the radio spectra of the southern shell of Cygnus Loop.

\[ E_{CRs} = 14.7 \left( \frac{\nu_{GHz}}{B_{\mu G}} \right)^{\frac{1}{2}} \text{GeV} \] (Reynolds 2008)
The high-frequency radio observations of evolved SNRs allow us to assess the maximum energy of accelerated CRs and magnetic field strength in the evolved SNRs.

Perform the characterization of the radio spectra of the southern shell of Cygnus Loop.