Tycho SNR: ambient medium structure by analysis of the supernova remnant

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SNR images as diagnostic tools

A wealth of observational data on SNRs is available: fluxes, integral spectra, spatially resolved density, spectra, local features on the radio and X-ray maps, radio and X-ray maps of brightness, polarization, etc. However, not all the data available are exploited. In particular, spectra, non-uniformities of the brightness distribution, and the density gradient of the ISM are not used in this approach. While the overall SNR is well studied, in general, there are few maps available with high spatial resolution. The method is based on a numerical approach to problem solving, which we use as input for 3D MHD simulations of Tycho SNR within the approach (a).

Tycho SNR: radio and X-ray maps

Simple procedures are applied to the maps in order to obtain spatial distributions of the synchrotron break frequency, synchrotron emissivity of the exponentially cut-off electron distribution, and magnetic field strength. Images, maps, and spectra are computed for the expansion and remodeling stage of the supernova remnant.

Image processing

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Density map

• There is evidence for large-scale ISM density gradient.
  • The acceleration center (green cross) is shifted from the geometrical center (yellow cross) along the gradient toward NW, as shown by Xue & Schaefer (2015).

MF and density around Tycho SNR

• The ambient MF gradient is along the Galactic plane, and the MF limbs are around the perpendicular shock. Tycho SNR seems to be barrel-like.
• The largest $\nu_{\text{break}}$ is in the very thin outer shell.
  • It increases toward the edge, like in the very narrow remnant spectral analysis of SN1006 (Katsuda et al. 2010).

Conclusions and References

The simulation methodology was generalized to SnR existing in ISM with non-uniform distribution of density and magnetic field. The approach to the radio maps is analyzed by Orlando et al. (2007) and to the X-ray maps by Orlando et al. (2011). The method was also applied to different beds with good convergence and the highest possible resolution. It is possible, for example, to separate the thermal from nonthermal X-ray maps of Tycho SNR. For $\nu_{\text{break}}$ from the radio maps, one is able to determine the magnetic field (MF) strength in the limbs of SNRs (Petruk et al. 2012). Here, we report the application of the approach to the Tycho SNR, which allows approximate evaluation of the ambient conditions around SNR which are used as input for 3D MHD simulations of Tycho SNR within the approach (a).

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Magnetic field map

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